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CONTENTS

	PAGE
Health and Environmental Conditions in the Iron Foundry. G. F. KEATINGE AND N. M. POTTER	125
Trichlorethylene: Absorption, Elimination and Metabolism. JOAN F. POWELL	142
Added Infection in Industrial Wounds. BARBARA CLAYTON-COOPER AND R. E. O. WILLIAMS	146
Hot Humid Environment: its Effect on the Performance of a Motor Co-ordination Test. J. S. WEINER AND J. C. D. HUTCHINSON	15
Education in Industrial Health: Report of the Education Committee of the Association of Industrial Medical Officers	158
Leading Articles:	
Education in Industrial Health. LORD MORAN	166
International Industrial Medicine	166
Trichlorethylene	167
Ophthalmology in the Factory. IDA MANN	169
Reviews	171
Abstracts	172
Proceedings of the Association of Industrial Medical Officers	178

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HEALTH AND ENVIRONMENTAL CONDITIONS IN THE IRON FOUNDRY

BY

G. F. KEATINGE and N. M. POTTER

From the Medical Department, The Butterley Company, Derby

This survey is largely based on experience gained in the foundries of the Butterley Company. Number 1 Foundry produces small, medium and light castings on a semi-mechanized basis and very light castings on a fully mechanized unit, while Number 2 Foundry makes large castings of a general nature. More than 200 workers are employed in the foundries, of whom 14 are engaged in fettling, 50 in moulding, 40 in core-making and the remainder in other work. Some 12 women are also employed in the fettling of small castings. The work done is representative of many branches of ironfounding; the building and general environment are of a kind very usual in the industry and for this reason it is felt that conclusions based on experience of these foundries can lay some claim to give a picture of the ironfounding industry as a whole.

Foundry Methods

Ironfounding is the process of casting in iron by running molten metal into a mould of the required shape taken in sand or loam. The material forming the mould is caused to take up the appropriate shape by means of a pattern which can be regarded as a 'positive', the mould a 'negative' and the casting itself a 'positive'. There is a considerable difference in the technique of manufacture used for moulding in sand and loam so it will be convenient to consider them separately.

Sand Moulding

This method of moulding is used to make all smaller castings, and as they are often required to be produced in large numbers, mechanized systems are much in use for this type of work. A mechanized unit comprises sand preparing plant (see fig. 7), moulding machines (see figs. 1 and 8), mould conveyors and 'knock out' (see fig. 10). The patterns are made of wood, plaster or metal, and it is essential that they be made as perfect as possible because the labour employed is chiefly unskilled.

The moulds are usually made in two sections in moulding 'boxes' which, however, are not boxes in the true sense of the word as they possess sides only and have neither floor nor roof. The moulding boxes are placed on top of the pattern which is fixed on the moulding machine and are filled with sand or loam from an overhead hopper. The sand must be under rigid control and may possess either a natural bond or have added to it a synthetic bonding substance (both of which contain a proportion of alumina) the latter having an addition of coal dust to give skin finish. After the box is filled with sand it is rammed hard mechanically and then turned upside down, so that the impression of the pattern is now uppermost.

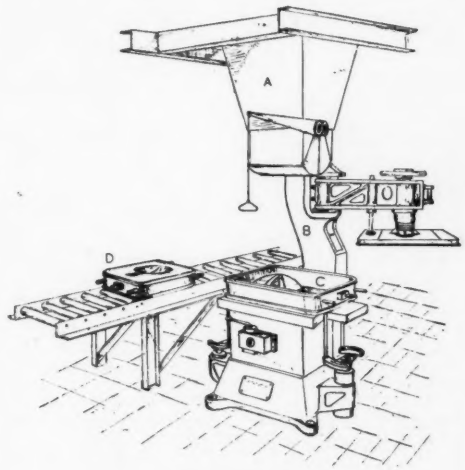


Fig. 1.—Machine moulding method.

A. *Overhead hopper.* B. *Main column upright.* C. *Moulding box with pattern.* D. *Completed half mould.*

Both sections of the mould are dealt with in this manner, but it is obvious that many internal spaces cannot be formed by a pattern directly in the sand and provision for these has to be made by means or 'cores' which are inserted after the pattern has been removed. Cores are generally made of a silica sand bonded with molasses and linseed oil, or a proprietary brand of binder which may be had in either a semi-solid or liquid state. All cores are baked in either a fixed or continuous stove which may be either coke or gas fired.

Cores, if required, are inserted in the appropriate places and one-half moulding box is turned so that the impression of the pattern in the sand faces downwards and the two sections are then approximated. The mould is now complete and awaits the pouring of the molten metal through a special aperture left for the purpose known as the pouring basin.

The metal is melted in a cupola or forced draught furnace and when ready it is run into special ladles by which it is transported to the moulds into which it is to be poured. In addition to the pouring basin, exits known as ' risers ' are sometimes added to enable the gases to escape on the introduction of the molten metal.

The moulds are now placed on the conveyor after which the metal is poured and the boxes are moved mechanically to the ' knock-out ', the point at which the contents are to be removed from the box by knocking or hammering by hand. In the course of the journey, while cooling is taking place and the metal is becoming solidified, a good deal of fume is given off, chiefly due to the burning of the core oil. There is also a considerable amount of dust and fume associated with the knock-out. This takes place over a grid through which the used sand is collected on to a conveyor belt running under the floor of the shop and by which it is carried to elevators (see fig. 7). These in their turn take the sand to the mixing plant where it receives an appropriate amount of fresh sand and is then again ready for use.

After having been knocked out the casting may still retain the pouring basin and possible ' risers ' and these, having served their purpose, have to be removed as well as any cores and sand which may remain adherent to it.

Excrescences of metal on the surface of the casting such as appear at the point of junction of the two halves of the moulding box have also to be dealt with and this is done by means of a pneumatic chisel or by a mechanized appliance, such as a rumbler or wheelabrator. The essential feature of both these pieces of apparatus is to cause the castings to be kept in motion while at the same time their surfaces are abraded by small shot or rather larger pieces of metal placed inside the machine for this purpose. The cleaning of the castings is completed on a grinding wheel, either fixed or movable (see fig. 12).

Hand manufacture of smaller castings follows essentially similar lines, but it is a slower process and all gradations exist from completely hand manufactured articles through a semi-mechanized system to the highly mechanized unit already described.

Sand moulding is also used for the manufacture of large castings, but the principle involved is the same, namely, pattern > mould > casting, although, of course, a large casting cannot be made in a ' box ' but needs special construction on the foundry floor. In both sand moulding and loam moulding for the making of large castings, the moulds and cores must be dried, and blacked with a mineral blacking.

Loam Moulding

Loam, a wet and plastic sand mixture, is employed for making the moulds required for some large heavy work.

The building up of the mould starts from a cast-iron bottom plate upon which bricks are placed and ' bedded ' to each other with wet or putty loam in order to give the rough outline desired. When this has been done, wet loam is applied to the face and the true contour of the mould is then obtained by the use of a strickle or shaping board. The strickle board is constructed of wood in the exact shape needed and works from a spindle set up in the centre of the mould. In most cases the core is made in a similar manner (see fig. 2).

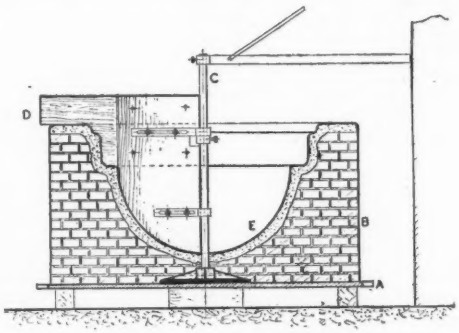


FIG. 2.—Loam moulding method.

A. *Cast iron bottom plate.* B. *Bricks ' bedded ' together with wet or putty loam.* C. *Centre spindle.* D. *Strickle or shaping board.*

Pouring of the metal is carried out as has already been described under sand moulding, but the cleaning of large castings is a difficult process. They can be placed in a sand blasting chamber which is sealed off from the body of the shop and in which an operator provided with suitable protective clothing, including an air helmet, directs a current of compressed air and sand on to the casting. This method is not practicable in all cases, as for example the very large casting, and until recently it has only been possible to carry out the fettling in these cases by hand or with the help of pneumatic chisels and swing frame grinders.

A new method known as hydro-blasting has, however, been devised in the United States of America, by means of which a high velocity jet of sand and water is projected on to the castings, thereby removing moulding material, cores and scale (see fig. 13). In addition the method keeps the atmosphere free from dust. If these claims are substantiated, this method may be one important solution of the dust problems in this industry.

ENVIRONMENTAL STUDIES

Heating and General Ventilation

Table 1 shows the results of the readings taken with the kata thermometer (dry bulb) as well as

recordings of the whirling psychrometer. These findings show the ventilation to be adequate and the cooling power satisfactory for the type of work being done so far as it is possible to assess. For a shop in which it is obviously difficult to regulate the heat, from the nature of the work, these figures cannot be regarded as unsatisfactory.

TABLE 1
SURVEY OF THE EFFICIENCY OF FOUNDRY HEATING AND VENTILATION

Position	Date of reading	Hour of reading	Temperature assessed by whirling psychrometer		Cooling power by kata thermometer Dry bulb		Air velocity (feet per minute)
			Wet bulb	Dry bulb	Head level	Floor level	
Foundry No. 2	26.2.43	10·15	53	55	11·0	9·5	100
Blackstone Bed	26·2·43	10·30	53	58	8·0	8·0	40
Foundry No. 1	26·2·43	10·50	53	62	8·5	—	65
Core shop ..	26·2·43	11·15	52	58	10·0	8·0	90
Core shop ..	18·1·45	14·30	50	52	12·75	10·0	120
Foundry No. 1	18·1·45	14·45	47	52	16·0	14·0	220
New fettling shop ..	18·1·45	15·00	47	50	10·0	11·0	40

Fumes

The fumes in the foundry are derived chiefly from the burning of bonding substances used in the core sand such as linseed oil, dextrine, resins or tar oils. Those given off by the resins are not unpleasant although the fumes derived from linseed oil are rather acrid; in general, however, they appear to be innocuous, except those produced from tar oils, which may possibly be carcinogenic.

Dust Hazard

It has long been known that certain foundry workers are subjected to abnormal dust hazards and many investigations have been carried out in the past, notably in Australia and America. Only a very limited investigation of the dust environment was possible in this survey, the work being restricted by time and availability of apparatus. The results, however, may form a useful introduction to a more comprehensive study, and the experience gained be of some value to subsequent workers in the subject.

In order that an estimate may be made of the potential danger of dust inhaled during any industrial operation, precise knowledge is required of the following four factors:

(1) The average concentration of the dust in the air breathed by the worker during the operation.

(2) The approximate time which the worker spends in this environment.

(3) The chemical composition of the inhaled dust.

(4) The size frequencies of the dust particles inhaled.

Technique

(*a*) *Collection of Samples.*—In making any decision as to the method to be adopted to give this information, the investigator must consider the various methods which he may have available, and assess each from a practical standpoint. Two factors must be emphasized. It is well known that the dust concentrations of a dusty occupation vary enormously so that 'spot' samples are of very limited utility. Secondly, it is known that the technique adopted will affect the magnitude of the estimates. Thus, results obtained with the Owens jet dust counter will generally be considerably less than those obtained with the Midget Impinger. Generally, the correlation between any two methods is very poor indeed. It is necessary, therefore, in presenting the results of an investigation that the technique employed should be rigidly defined.

In order that an average sample may be obtained over a lengthy period, and be subsequently submitted to analysis, two general methods are available, the Impinger and filtration. American practice has long favoured the former. Two criticisms may be advanced against the Impinger: transport and transfer of a liquid medium is inconvenient in a works; and secondly, the high speed at which the particles impinge on the base of the tube may fracture the larger particles, thus giving an erroneously high number when the particles are counted. The Briscoe crystal filter overcomes these difficulties.

The dust enters the filter at a low speed and may be recovered easily from the crystal bed and prepared for particle counts or analysis. The microscope slide may be prepared of a correct density to facilitate counting, a difficult procedure when using the Konimeter or similar spot methods. Although concentrations may amount to millions of particles per cubic foot, the actual weight of dust in suspension is so small that a micro balance is practically essential for the determination of mass concentration and chemical analysis.

Unfortunately we were unable to obtain such a balance in the time available, and the ordinary analytical balance was of a type unsuitable for adaptation to micro weighing. All weighings are limited to an accuracy of 0·2 mg., this being determined over a series of repeated investigations using a carefully controlled technique. So that maximum quantities of dust should be available for analysis, samples Nos. 1–7 were taken with a rotary hand pump attached to a large Briscoe filter. Five subsequent samples were taken with hand syringe (capacity 0·0055 cu. ft.) coupled to a simple micro-crystal filter, a number of which may be carried about ready loaded in a small box. A tubular extension was fitted to the filter, and the pump operated at a speed sufficient to draw in falling particles smaller than 35 microns.

(*b*) *Chemical Analysis.*—In view of the small amounts of dust available for analysis only a very limited empirical procedure is practicable. A portion of the collected dust was placed in a small platinum crucible made from foil and subjected to three processes in the crucible. (1) Ignition at 700° C. to determine the percentage of combustible matter. (2) Extraction with dilute hydrochloric acid to give the percentage of soluble material (mainly iron). (3) Evaporation with hydrofluoric acid and subsequent ignition to constant weight to remove the total silica. The greater part of the total silica would, in fact, be free silica in the samples examined. The residues of all samples were then bulked and the percentage of alumina determined after fusion with sodium carbonate.

Obviously the accuracy is dependent on the number of operations involved and the weight of the available samples. Without a micro balance the accuracy obtainable is low and since the analysis refers to all particles this may not be the same for all size frequencies.

(*c*) *Microscopic Methods.*—The method adopted for the determination of the number of particles and the size frequency of the dust has been described in some detail by Lowrie Fairs (1944). The portion of the collected dust not used in chemical analysis was agitated in alcohol. The dispersed suspension was then further agitated by means of air blown from a pipette. A drop on the end of the pipette was then transferred to a

haemocytometer cell and after allowing the sample to dry, the dust particles were counted and sized by means of a Patterson graticule in the eye-piece of the microscope. Having established the relative frequency of occurrence of each size of particle, a weighted average may be calculated assuming that the particles weigh the same as a cube of the same dimensions, the specific gravity being an average calculated for the dust. This has been shown to be approximately true. The number of particles present in the original sample in each size range may then be calculated. The method has two disadvantages. It is by no means an easy task to prepare an even deposit on a slide truly representative of the original dust. The total weight of the dust on the slide will only be a fraction of a milligramme. Again, only a small fraction of this deposit will be sized against the graticule. Secondly, the greatest weight of the dust will be in the large particles which are numerically insignificant. One particle 70 microns in diameter is equivalent in weight to 343,000 particles of one micron. Great care must be exercised in order that the proportion of large particles may be estimated correctly. Between 2000 and 3000 particles were sized for each sample. The process is, therefore, a laborious procedure. Furthermore, the microscope itself has limitations.

The microscope available was a Watson 'Edinburgh Student' fitted with mechanical stage and substage condenser (NA 1–0). A 16-mm. objective combined with a ×7 Holos eye-piece incorporating a Patterson graticule, was used for measuring particles in the range 10–70 microns. Particles below 10 microns in size were measured with a 4-mm. apochromatic objective. A blue light filter was incorporated to facilitate the observation of the smallest particles. The resolving power of a microscope depends largely on the wavelength of the light source and the numerical aperture of the objective and substage condenser. Particles much below 0·5 microns in size cannot be discriminated with the apparatus. Since the numerical proportion of particles below 1·5 microns in size is very large it is apparent that microscope counts are subject to large variations according to the apparatus available and possibly also to the observer, since particles near the visible limit are exceedingly difficult to define. In spite of the limitations outlined above, and the development of other micro methods for the determination of size frequency and total surface area, the microscope is still the most positive method available and probably the most satisfactory.

Location of Samples

All samples were taken from a position near to the operative's mouth unless otherwise stated. Generally the filter was inverted and the air intake speed adjusted so that only particles less than 40 microns in size would be included in the sample. In actual practice particles much larger than this are projected at high speed by certain processes and are retained by the filter. In the case of two samples (Nos. 1 and 7) the proportion was so excessive that particles in excess of 70 microns were removed by sieving the dust samples on a micro-sieve. If more than one operator was engaged on similar work the sample was divided between the various workers. Samples generally took about one hour to collect.

Sample No. 1. Medium Fettlings. The site was in the old Fettling Shop for the treatment of castings up to about 3 cwt. Over a period of more than one hour three fettlers were sampled. The fettlers used compressed-air picks. It was noticed that the worst atmospheric conditions were prevalent when cleaning off the dust by the process of 'blowing off' with the nozzle. In addition, dust was blown into the operator's face by the exhaust when cleaning the inside of castings. The actual fettling may occupy one-third to one-half of the worker's time. A fair current of air was moving across the shop.

Sample No. 2. The general body of No. 1 Foundry. In order to collect a maximum amount of dust for analysis the filter was placed facing upwards for this sample. No machinery was nearer than 12 ft. The location was away from, but surrounded by a variety of foundry processes. These included medium and fine fettling, pneumatic and spray-type mould fillings, shaking out of moulds, wheelabrating, metal pouring and rumbling. Sampling was continued for 35 minutes.

Sample No. 3. Mould Filling. This sample was taken at the breathing level of two mould fillers during the actual operation of the pneumatic filling. Dusting, brushing and blowing off processes were not included in the sample although residual pollution from these sources may still have persisted. This sample, therefore, only refers to the actual filling of the mould and tamping off. The moulds were of moderate size and took from 10 to 14 seconds to fill. Not more than one-seventh of the worker's time was spent on this operation.

Sample No. 4. The 'Knock out'. This sample was taken during the emptying of the moulds after partial cooling. The moulding material was emptied over a grating. Fumes were excessive, but this did not appear to be a particularly dusty occupation. One operator possibly spent one-third to one-half of the working shift actually knocking out the moulds.

Sample No. 5. Defective Wheelabrator. The airborne dust was sampled about four feet from the wheelabrator. A considerable dust cloud was carried towards No. 1 Foundry during operation. This machine is working for about one-third of the shift and although workers were not in the immediate vicinity, dust was carried towards No. 1 Foundry and in the path of several workers. The machine is due for immediate replacement.

Sample No. 6. Small Fettlings. The small fettlings are carried out in a shop adjoining No. 1 Foundry. It is a new shop and is cleaned regularly. The conditions compare very favourably with the rest of the foundry as regards house-keeping. One-half of the sample was taken from the breathing level of an operator working a Spenser Duplex high-speed grinder. This operator was the only one observed to be wearing a mask. The shop is used exclusively for grinding off excess metal from light castings. The second half of the sample was obtained during the operation of a small pneumatic carborundum high-speed grinder. There were several of these machines in operation and none were fitted with dedusting devices. The compressed air exhaust did not appear to aggravate the dust nuisance and conditions appeared relatively clear in the shop. Probably operators are grinding about three-quarters of the shift.

Sample No. 7. Large Fettling. This work was carried out near the closed end of one shop. Castings were very large (up to 10 tons) and fettling occupies probably two-thirds of the shift. The sample covered two fettlers cleaning three large castings. Much dust was observed to be dispersed into the air during the blow-off period. Air conditions were comparatively static in this part of the foundry.

Sample No. 8. Core Shop. This shop is an annexe to No. 1 Foundry, and as with Sample No. 6 conditions are no doubt improved by this arrangement. The mixture, which is hand filled by girls, consists of sea sand, 'Cordex' (an artificial bonding substance), and linseed oil. . Sixteen workers were employed and the work was practically continuous. All these workers contributed to the sample.

Sample No. 9. General Body, No. 1 Foundry. The sample was taken in about the middle of No. 1 Foundry. Immediately opposite was a large opening into No. 2 Foundry. A 'Slinger', working about 20 per cent. of the sampling time, was situated 10 ft. away.

Sample No. 10. General Body, No. 1 Foundry. The sampling position was 37 yd. from the top end of No. 1 Foundry, and was situated in the space between two large moulds which were in the process of being filled. Large moulds were being constructed nearby.

Sample No. 11. General Body, No. 2 Foundry. Sampling position was 37 yards from the top end of the foundry. A large mould was being filled close by the position and this part of the foundry was very busy with various operations in the vicinity.

Sample No. 12. General Body, No. 2 Foundry. The sample was taken in the centre of the foundry immediately opposite a large annealing oven.

Discussion of Results

The mass concentration of each sample is given in Table 2 and the chemical analysis in Table 3.

TABLE 2

MASS CONCENTRATION OF AIRBORNE DUST AT BREATHING HEIGHT

Sample No.	Location or occupation	Wt. of dust (mg.)	Vol. air sampled (cu. ft.)	Mg. per cu. ft.	Mg. per cu. metre
1*	Medium-sized fettlings ..	71·7	20·74	3·46	122·1
2	Main Body, No. 1 Foundry	19·2	16·00	1·20	42·4
3	Pneumatic mould filling	23·6	11·20	2·11	74·5
4	Shaking-out ..	15·6	13·39	1·16	40·9
5	Defective wheelabrator	31·6	9·18	3·44	121·4
6	Small fettling ..	14·3	15·39	0·93	32·8
7*	Large fettling ..	48·2	10·00	4·82	170·0
8†	Core shop ..	1·3	5·55	0·23	8·2
9†	Main Body, No. 1 Foundry	1·7	5·55	0·31	10·8
10†	Main Body, No. 1 Foundry	2·9	5·55	0·52	18·4
11†	Main Body, No. 2 Foundry	2·2	5·55	0·40	14·0
12†	Main Body, No. 2 Foundry	2·2	5·55	0·40	14·0

TABLE 3

CHEMICAL ANALYSIS OF AIRBORNE DUST

Sample No.	1	7	3+4	2
Wt. of sample analysed (mg.)	52·8	29·8	14·0	8·8
Per cent. loss on ignition (combustible matter) ..	10·0	8·0	21·0	41·0
Per cent. soluble in hydrochloric acid (mainly iron, etc.)	11·0	18·0	11·0	18·0
Per cent. total silica (loss with hydrofluoric acid)	67·0	68·0	50·0	20·0
Per cent. residue	12·0	6·0	18·0	21·0
Per cent. alumina (Al_2O_3) in residue	30			

The weight distribution and the number of particles per cubic foot for a limited range of size frequencies

* From samples 1 and 7 dust over 70 microns in size was removed by a micro-size sieve. Including this oversize dust the concentrations were 5·77 and 5·22 mg. per cu. ft. respectively.

† Samples taken with micro filter and hand syringe.

TABLE 4

WEIGHT DISTRIBUTION AND PARTICLES PER CUBIC FOOT

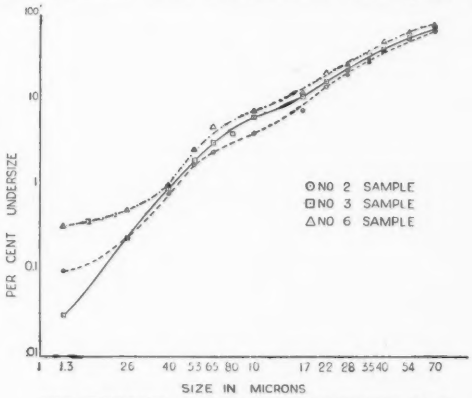
1. NUMBER OF PARTICLES PER CUBIC FOOT

	Sample No. 1 Medium fettling	2 General body	3 Pneumatic filling	4 Shake out	6 Small fettling	7 Large fettling
Sp. gr. (calc.)	2·65	2·4	2·4	2·4	4·0	2·65
Size in microns	(Number of particles $\times 10^6$)					
≥ 35	0·005	0·002	0·004	0·002	0·001	0·004
$\geq 20 - < 35$	0·011	0·006	0·01	0·006	0·003	0·031
$\geq 6 - < 20$	0·095	0·054	0·108	0·071	0·037	0·607
Less than 6 ..	4·84	1·81	3·55	2·625	2·27	27·57
Total particles per cu. ft. ..	4·95	1·88	3·67	2·704	2·31	28·20
Total particles per c.c. ..	175·000	66·000	129·000	95·000	81·000	995·000

2. WEIGHT PER CENT.

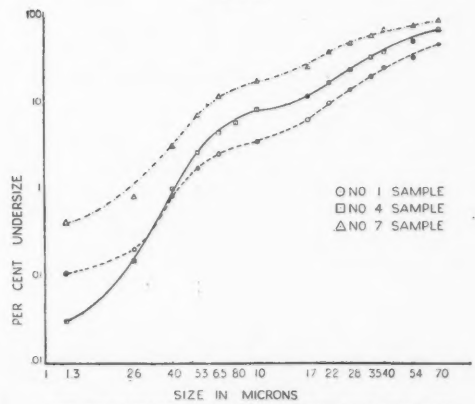
≥ 35	73·3	61·8	60·0	59·1	51·9	28·9
$\geq 20 - < 35$	16·4	23·8	23·5	22·9	27·5	31·3
$\geq 6 - < 20$	7·6	12·0	13·3	13·3	15·8	27·6
Less than 6 ..	2·7	2·4	3·2	4·7	4·8	12·2

is shown in Table 4. The percentage weight undersize for each particle size is graphed in fig. 3 and 3*a*, on a log-log scale. In order to show the relationship between mass concentration and particle



SIZE FREQUENCY CURVES OF AIRBORNE FOUNDRY DUSTS

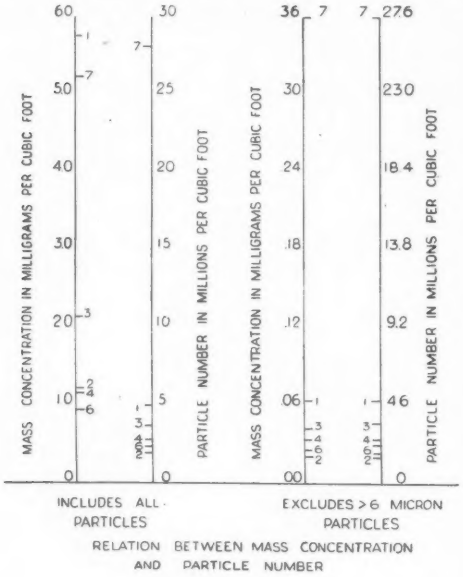
FIG. 3.



SIZE FREQUENCY CURVES OF AIRBORNE FOUNDRY DUSTS

FIG. 3A.

number per cubic foot a diagram has been prepared (fig. 4 and 4*a*) showing the effect of exclusion of large particles on the mass concentration and particle count. The mass concentration shows at


MASS CONCENTRATION IN MILLIGRAMS PER CUBIC FOOT
PARTICLE NUMBER IN MILLIONS PER CUBIC FOOT
MASS CONCENTRATION IN MILLIGRAMS PER CUBIC FOOT
PARTICLE NUMBER IN MILLIONS PER CUBIC FOOT
INCLUDES ALL PARTICLES
EXCLUDES > 6 MICRON PARTICLES
RELATION BETWEEN MASS CONCENTRATION AND PARTICLE NUMBER

FIGS. 4 and 4A.

once that the medium and large fettlers have the dustiest occupation. The defective wheelabrator is a large source of pollution, but this pollution does not appear to have affected conditions materially in the general body of the foundry. The vast majority of workers spend most of their time in the conditions revealed by samples taken from the general body of the foundry. These show a rather striking constancy when due allowance is made for sample No. 2 which included particles of all sizes. Conditions appear to be better in small shops such as the small fettling and core shop. Cleaner housekeeping is possible in these circumstances and the effect is reflected in lower dust concentrations. The situation of these shops in annexes off the main foundry mitigates the effect of pollution from this source.

Chemical analysis shows that the dust from medium and large fettling consists largely of silica particles. This was confirmed by the microscope. Although it is impossible to identify very small particles it is reasonable to assume that these particles are similar in chemical composition to the large particles. The pollution in the general body of the foundry is definitely higher in combustible matter and lower in silica content.

The character of the airborne dust produced during the filling of moulds and the shake out is intermediate between the extremes of large fettling and general body, but since the mass concentrations are much lower and the time spent by the operator in these occupations is much less the silica hazard is much lower than that of the fettler.

Microscopic examination of the dusts shows that numerically 96–98 per cent. of the particles are less than 6 microns in size. The actual weight of this fraction may be less than 3 per cent. of the total weight of dust. Since the dust which may be retained by the lung tissue is above the resolving limit of the microscope and below 6 microns in size, it follows that mass concentrations without numerical counts cannot provide a true measure of the dust hazard unless special precautions are taken to exclude particles in excess of the upper size limit. This is strikingly illustrated by a comparison of samples Nos. 1 and 7 (fig. 4 and 4*a*). Including all particles, sample No. 1 gave a slightly higher concentration than sample No. 7. The particle count, however, showed that the hazard for the large fettler (No. 7, 995 particles per c.c.) was more than five times that of the medium fettler (No. 1, 175 particles per c.c.). The airborne dust from the latter source is much coarser than that produced from the former (fig. 3*a*). This may be due to the nature of the process although it seems likely that air conditions may be partly responsible. The medium fettler is often working on the inside of castings, and in this instance there was a definite ventilation current across the shop. Large particles projected from a process at high velocity are only partly deflected by air currents whereas small particles will tend to be carried away from the worker. If due allowance is made for the higher silica content of the air breathed by the large fettler, then the silica hazard of this worker is fifty times that of a worker in the general body of the foundry. Medium fettling represents a nine times greater hazard, and pneumatic mould filling and shaking out no more than five times. Owing to the relatively short time actually spent by the worker on these processes the dust hazard will be much less than is indicated above. Large particles of coal dust were prevalent in the air of the main body (sample No. 2) and in the samples from pneumatic filling and the shake out (Nos. 3 and 4). This last included many particles which were partly coked, and in view of the excessive fumes breathed by the worker the harmful effects of tar cannot be ignored. The sample from the small fettling shop consisted largely of iron and carborundum particles, and the concentration would not appear to be excessive. Although the workers in the core shop are handling a sand mixture most of their time, the nature of the mixture with the linseed oil binding is such that air pollution from this source is very low indeed (sample No. 8). Micro samples from the main body of the foundries (Nos. 9, 10, 11 and 12) show that there is no excessive pollution in the foundry atmosphere judged by internal standards.

In the routine control of atmospheric pollution such as that which exists in the foundry, measurement of mass concentrations represents the simplest way of keeping a check on changing conditions.

Fig. 4 and 4*a* show very clearly that if the large particles could be excluded, then the mass concentration would also enable the dust hazard to be measured accurately. This presents some difficulty for samples which are made up partly of high-velocity particles. The terminal velocities of quartz particles falling in still air are given in Table 5. By adjusting the air intake speed to the filter, and fitting a long tubular extension to it, the exclusion of the larger particles does not appear to be impracticable. The intake tube would need to be fitted with a smoothing device and to have a right-angle bend in order to stop high-speed particles. If the air intake speed were adjusted to exclude particles greater than 10 microns, then the concentration would be a fair measure of the dust hazard. Whilst the cut-off of particles larger than 10 microns in size should be reasonably sharp, only a fraction of those just below this size limit would be included in the sample. The proportion would increase rapidly as the motion of the particles became more dependent on the movement of the air current in the low size-frequency ranges. With this method a micro balance sensitive to 0·01 mg. would be essential.

TABLE 5

FREE FALLING SPEED OF QUARTZ PARTICLES IN AIR

Particle diameter (in microns)	Approximate terminal velocity (cm. per sec.)
·100·0	41·0
75·0	30·0
50·0	12·5
30·0	4·5
10·0	0·5
5·0	0·1
2·5	0·03

As an alternative to this procedure, the microscope can give a good estimate of the total number of particles below 6 microns in size, providing a size-frequency curve is not required. In this case the inclusion or exclusion of large particles from the sample is immaterial. Having obtained a satisfactory average sample by means of the crystal filter and hand syringe, the crystals may be separated from the dust by means of a hand centrifuge. The dust may then be agitated in a definite volume of alcohol. After agitation a suitable quantity of the suspension is quickly removed by means of a micro pipette and transferred to a moist chamber microscope slide. When the slide has dried and a suitable deposit of sufficient density obtained, counts may be made at random parts of the deposit by means of the 4-mm. objective only, with a Patterson graticule in the eye-piece, ignoring the particles above 6 microns in size. Having established an average count within the rectangle of the graticule, simple calculation will give the total particle count on the slide and so the total particles in the original suspension. Much of the trouble in preparing a slide from a suspension is in obtaining a representative sample of the large particles. Since these are numerically insignificant, and of little interest from the point of view of the health of the worker, the sampling difficulties and the necessity to undertake a great many size comparisons would largely disappear with this technique. The actual count and calculation would not take more than an hour and since the moist chamber will hold a relatively large volume of liquid (0·3 c.c.) the error from this is much less than that incurred by using the standard haemocytometer cell. After filling the cell, the chamber should be allowed to stand at room temperature when an even deposit of the dust in suspension will be deposited on the slide.

HEALTH STUDIES

Although some indication of diseases to which the foundry worker is subject can be obtained from a study of the Occupational Mortality figures of the Registrar-General's Decennial Supplement (1931) the figures are apt to be misleading for a variety of reasons. It has therefore been found advisable to restrict this part of the investigation to known facts within our own experience, namely, the incidence of sickness and accidents among foundry workers compared with a similar number of workers in another department.

Sickness and Accidents

The reaction of the foundry man to his environment has been attempted by comparing the nature of the absence due to sickness and accidents occurring in the Foundries with that taking place in the Constructional Department at Butterley during the past twelve months. The Constructional Department has been selected for comparison not only because there is not an undue disparity between the numbers employed in it and the foundry respectively, but also because the Registrar-General's Decennial Supplement (1931) showed no significant rise in mortality among constructional engineers due to conditions other than accident, unless a possible significant excess of cancer deaths is taken into account.

The results of these studies are shown in Fig. 5 and Table 6, and it will be seen that contrary to what might have been expected, the number of cases of respiratory disease occurring in the Foundries was lower than in the Constructional Department, although the average number of days lost per case was higher. Affections of the skin showed a greater incidence though rheumatic cases were in about the same proportion, but accidents were fewer and less time was lost from this cause, despite the fact that two cases of herniotomy are included in the accident figures.

Respiratory Disease

The fact that the average number of days lost per case due to respiratory disease is more in the Foundries than in the Constructional Department suggested that the nature of the respiratory conditions might be of a more serious nature among

TABLE 6

CASES OF SICKNESS AND ACCIDENT ABSENCE IN THE FOUNDRIES AND CONSTRUCTIONAL DEPARTMENT AT BUTTERLEY

Nature of condition	Foundry		Constructional	
	Number of cases per 100 persons employed	Average number of days lost per 100 persons employed	Number of cases per 100 persons employed	Average number of days lost per 100 persons employed
Respiratory disease	26·9	492	39·7	417
Skin	9·0	130	3·2	94
Rheumatic disease	8·0	108	8·1	117
Psychoneurosis	1·9	59	2·5	29
Gastro-intestinal	8·0	79	9·0	172
Genito-urinary..	0·9	21	0·4	2
Circulatory ..	2·0	36	3·9	59
Miscellaneous ..	17·8	77	6·0	71
Operations ..	—	—	1·3	19
Infectious diseases	—	—	2·1	20
Accidents ..	14·6	217	15·2	345

Foundries (219 workers), Constructional (282 workers).

workers in the foundries, due possibly to the dusty atmosphere, so an investigation was carried out to determine the extent to which dust had affected the lungs. Sixty men working in the Foundries were examined and a full history, including a complete occupational history was taken from each person; this was followed by a physical examination including chest radiography, and the results of this investigation are shown in Table 7. Table 8 gives in summary form the results of the x-ray survey in the different age groups of those examined, while in Table 9 is given the length of time to which those examined were exposed to a dust risk. No cases of tuberculosis or silicosis were noted.

Butterley is in a coal-mining district and the investigation was complicated by the fact that the occupational history of a number of those examined included coal mining, itself a dusty occupation. Neither of the fettlers showing lung changes, however, had been at any time engaged in colliery work, although two out of the eight moulders had been coal miners and two out of the three noted amongst the other occupations.

This investigation indicates, therefore, that 21 per cent. of all the foundry workers examined showed some evidence of dust changes in the lungs, but 40 per cent. of fettlers were affected in comparison with 25 per cent. of moulders and 12 per cent. of other workers: moreover the degree of dustiness in the fettlers' lungs was much heavier than in the case of other workers in the foundry.

In general the degree of dustiness of the lung depends on the length of exposure to the dusty environment and, although there is some idiosyncrasy, exposure of many years duration is usually necessary before any marked changes occur. Thus, in the case of the fettlers, those showing evidence of dust in the lungs had been exposed to risk for over twenty years.

Although the total number of those examined is small, the results are largely in accordance with the findings in other and more extensive surveys of a similar nature (Sander, 1938; McConnell & Fehnel, 1934) indicating that there is a greater risk of the occurrence of dust changes in the fettler than in other workers in the foundry. That dust changes should occur more commonly in the lungs of the fettler is not surprising in view of the mass concentration of the dust, the size of particles, and the

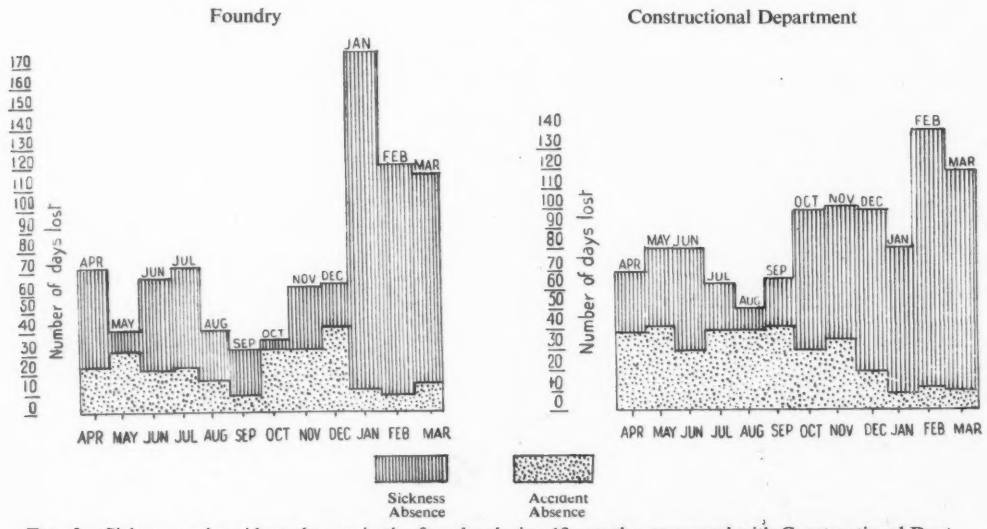


FIG. 5.—Sickness and accident absence in the foundry during 12 months, compared with Constructional Dept. (The number of days lost is calculated for each hundred persons employed.)

FIG. 6 (above).—View of a well laid out semi-production foundry. Note high standard of general cleanliness and the effect of good general lighting.

FIG. 7 (below).—Sand-preparing plant. Modern methods of mechanization prevent dusty atmosphere.

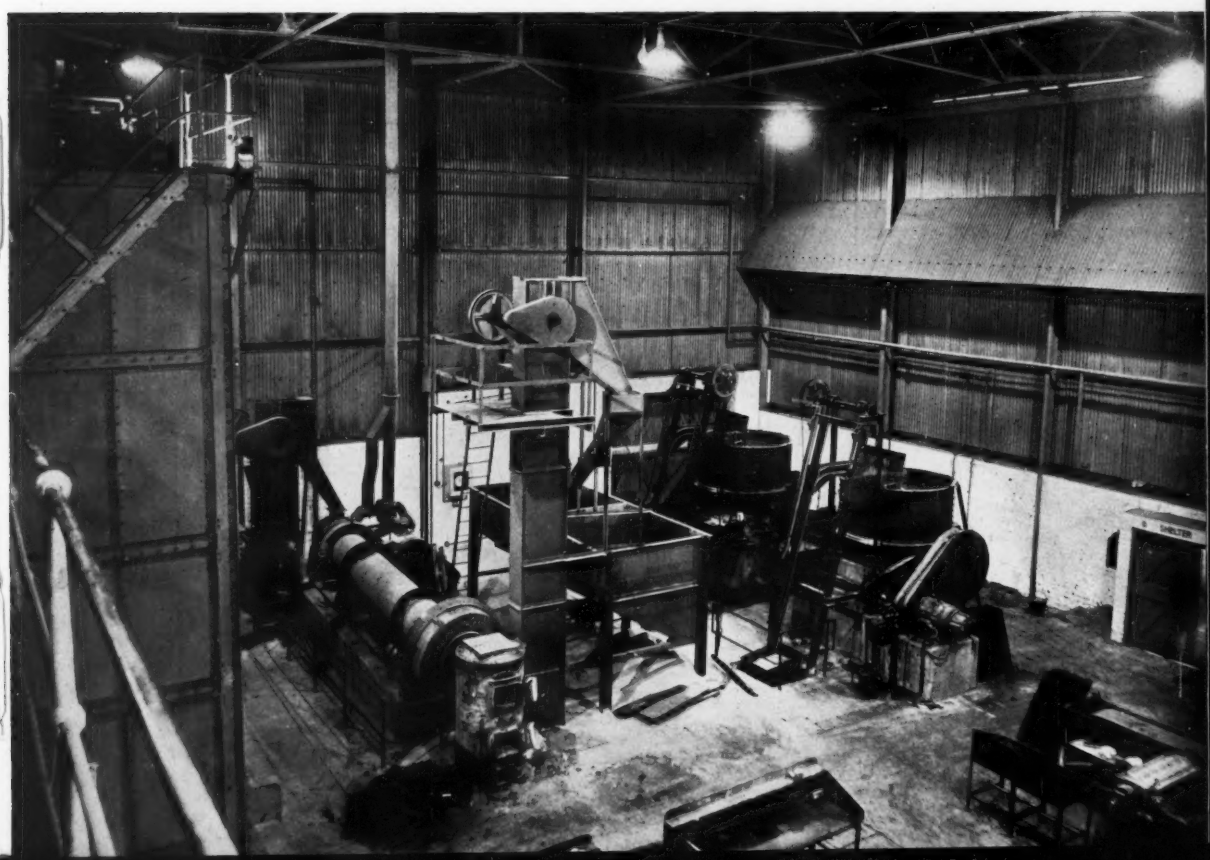


FIG. 8 (above).—Moulding machines and conveyor system for moulds.

FIG. 9 (below).—Core making. Note absence of visible dust on clothes of operators.

FIG. 10 (above).—The ' knock-out '. The men on the left separate the mould boxes; the sand on the casting is then knocked out with a hammer. The semi-clean casting is then conveyed to the fettling shop.

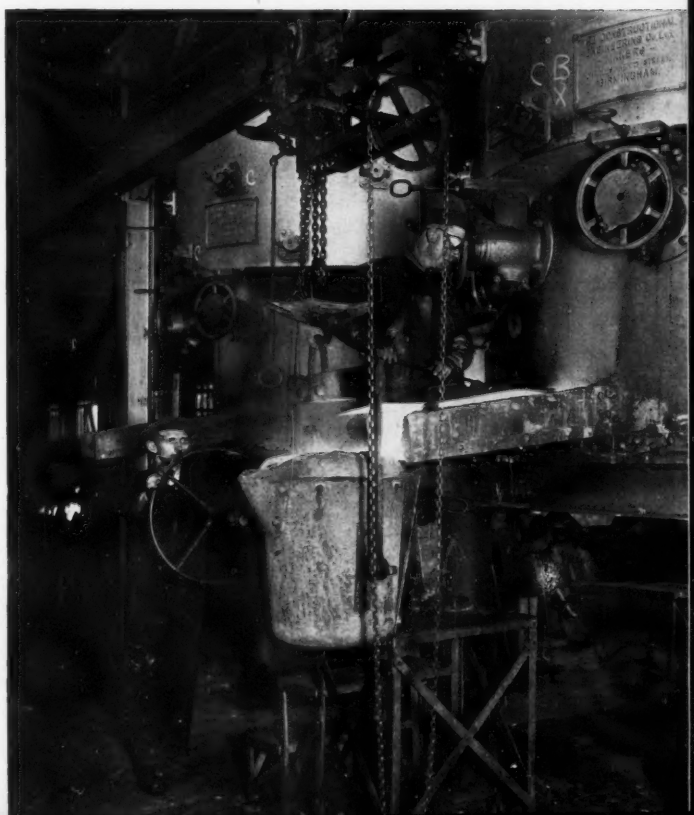


FIG. 11 (right).—Tapping the cupola. The molten metal (at 1400° C.) in the ladle is then in turn poured into the mould.

FIG. 12 (above).—High-speed swing-frame grinder using bakelite bonded wheel. Note absence of local exhaust system.

Fig. 13 (below).—Hydro-blast in action. The operator wears full protective clothing including helmet to which clean air is supplied. The stream of water and sand has a velocity of 3 miles per minute.

TABLE 7

OCCUPATIONAL HISTORY AND LUNG CHANGES AMONG 60 FOUNDRY WORKERS

Case No.	Age	No. of years engaged in Foundry work	Previous employment in other industry	Principal occupation while employed in Foundry	Present occupation and how long	X-ray Class *
486	46	21	Nil.	Fettling.	Fettling 21 years.	III
403	24	9	Nil.	Moulding.	Core shop 5 years.	I
419	24	4½	Cutting silk from bobbins.	Moulding.	Moulding 4½ years.	II
556	54	5	Pottery: on clay modelling wheel 13 years; H.M. Forces 2 years; colliery: weighing coal 20 years.	Sand drier.	Sand drier 5 years.	II+
555	48	24	Nil.	Moulding.	Core Shop.	II
518	47	12	Acetylene burning, Constructional Eng. Shop; colliery roads 2 years; coal-getting 6 years.	Cupola Works.	Cupola Works 12 years.	II
401	23	8	Pit Bank 1 year.	Moulding.	Moulding 8 years.	II
479	30	4	Iron rolling mills 11 years; Celanese 2½ years.	Moulding.	Moulding.	III
428	24	6	Pit 10 weeks.	Mechanized Sand Plant.	Mechanized Sand Plant 6 years.	III
410	24	10	Nil.	Moulding.	Moulding 10 years.	II
380	21	6	Errand boy 1 year.	Moulding.	Moulding 6 years.	II
433	26	12	Foundry crane driver 6 months.	Moulding.	Moulding 12 years.	II
406	42	22½	Stringing bobbins 6 months.	Moulding.	Moulding 22½ years.	II+
360	18	2	Pipe making: pneumatic hammer driver 1 year; pit bank 1 year.	Moulding.	Moulding 1 year.	II
385	20	5	Sand mixer 1 year; shop 1 year.	Moulding.	Moulding 4 years.	II+
373	23	7	Dismantling cases.	Moulding.	Moulding 7 years.	III
494	23	8	Nil.	Fettling.	Fettling 8 years.	II
368	17	1	Rivet carrier .	General labouring.	General labourer 1 year.	I
415	43	21	Colliery loader 3 years; textile factory 2 years; labourer 2 years.	Moulding.	Moulding 19 years.	III
537	65	3	Colliery: ganging 6 years; loading 10 years. Contractor 30 years. Navy 4 years.	Labourer.	Labourer 3 years.	I
558	55	10	Colliery: ganging 4 years; loading then getting coal for 27 years.	Labourer.	Sand Mixer.	II
534	40	8	Roadman 3 years; iron rolling mills. apprentice fitter in Canadian foundry 7 years.	Fitter.	Fitter 8 years.	II
525	40	12	Colliery surface work 14 years.	Labourer.	General labourer, night work, 12 years.	II
550	58	44	Nil.	Every job in turn.	Casting.	II
548	40	2	Colliery: coal face getting coal 23 years. Night porter 5 years. A.R.P. Warden 2 years.	Labourer.	Night labourer 2 years.	III
532	40	8	Colliery: surface work 1 year; roads 13 years. Bricklayer's labourer 5 years. Foundry labourer 1 year.	Cupola charger.	Copula charger 7 years.	II
515	47	2	Colliery: surface work 1 year. H.M. Forces 4 years. Blast furnace 28 years.	Cupola.	Cupola.	II
757	62	10	Pottery: making bottles 1 year. Colliery: pony driver 30 years. Constructional eng., carrying iron.	Cupola bank.	Sweeping up.	II
593	65	30	Colliery: firing boilers.	Moulding.	Moulding 30 years.	II
476	38	3	Sharpening pencils 1 year. Confectioner 8 years. Labourer on camp construction 1 year.	Grinding.	Grinding.	II
459	21	6	Nil.	Core shop.	Cores 6 years.	II
528	57	3	Surveyor's depot 13 years. H.M. Forces 4 years. Colliery surface 22 years.	Labourer.	Night labourer 3 years.	II
477	44	4	Labourer 1 year. Colliery: coal face 25 years.	Moulding.	Moulding 4 years.	II

* The method used for classification of the radiological appearances has been:
Class I.—Normal lung. *Class II.*—Increased markings but not beyond normal limits for a town dweller (+ indicates excessive markings). *Class III.*—Early reticulation. *Class IV.*—First stage silicosis. *Class V.*—Second stage silicosis. *Class VI.*—Third stage silicosis.

TABLE 7.—*continued*

Case No.	Age	No. of years engaged in Foundry work	Previous employment in other industry	Principal occupation while employed in Foundry	Present occupation and how long	X-ray Class*
641	64	33	Colliery: coal face 6 years. H.M. Army 4 years.	Moulding.	Moulding	II
611	27	10	Foundry: pipe making 2 years.	Cores.	Cores 10 years.	II
544	46	5	Colliery: blacksmith 2 years. Timbering, dattling 18 years. Colliery blacksmith 2 years. Foundry blacksmith 2 years. Air Ministry 6 months.	Fettling.	Fettler 3 years.	II
526	57	25	Stable boy and butler valet 10 years. Great War 6 years. Boilers 12 years.	Stripper.	Stripper 13 years.	II
487	36	21	Foundry fitter 6 years. Celanese: bobbin winding 1 year.	Fettling.	Fettling and grinding 21 years.	III
609	20	6	Nil.	Moulding.	Moulding and slingers 6 years.	I
562	60	40	Stone breaker 1 year.	Moulder.	Labourer 6 years.	III
556	60	6	Farm labourer and colliery loader 5 years. Labourer, furnace man.	Labourer.	Labourer 6 years.	III
497	34	13	Bricklayer 5 years.	Cupola repairs.	Cupola repairs 7 years.	II
489	24	9½	Foundry 1½ years. Hosiery mill.	Fettling.	Fettling 8 years.	II
406	24	10	Stripping bobbins 6 months.	Moulding.	Moulding 10 years.	II+
385	21	5	Foundry: sand mixer 1 year.	Moulding.	Moulding 4 years.	II+
367	41	20	Cotton mill: cleaner 3 years. Colliery: ganging 2 years; stall 3 years. Foundry labourer 2 years.	Moulding.	Moulding 18 years.	III
591	62	47	All jobs in iron foundry.	Loam moulding.	Loam moulding 30 years.	III
595	54	41	Sand mixing and core making.	Casting various.	Loam moulding 20 years.	II
594	51	40	Sand moulding 3½ years.	Loam moulding.	Loam moulding 8 years.	II+
615	15	11 months	Nil.	Core making 6 months.	Loam moulding 5 months.	I
614	38	23½	Iron foundry: pattern shop 2½ years; core making and moulding 6½ years.	Core making.	Core making 17 years	I
619	34	20	Farm labourer 1 year.	Moulding.	Moulding 20 years.	II
623	29	15	Nil.	Nil.	Moulder 15 years.	II
633	33	16	Labourer 1 year. Pipe foundry 2½ years.	General labouring.	Odd jobs, but mostly moulding 13½ years.	III
612	26	10	Turning shop slinger in foundry 9 months.	Core making.	Core making 10 years.	II
632	58	42	Railway porter 9 years.	Moulding.	Moulding 42 years.	II
629	46	23	Core making 2 years. Ships' stoker in summer, lumberjack in winter (6 years in Canada).	Moulding.	Moulding.	III
626	68	53	Colliery dattling 1 year.	Moulding.	Moulding 53 years.	II
628	53	39	Nil.	Moulding.	Moulding 39 years.	II

* The method used for classification of the radiological appearances has been:
Class I.—Normal lung. *Class II.*—Increased markings but not beyond normal limits for a town dweller (+ indicates excessive markings). *Class III.*—Early reticulation. *Class IV.*—First stage silicosis. *Class V.*—Second stage silicosis. *Class VI.*—Third stage silicosis.

nature of the dust to which he is exposed. The failure of the majority of foundry workers to show dust changes in the lungs may be attributed to the relatively small amount of free silica suspended in the air which they breathe, as well as to the presence of an appreciable percentage of alumina. The work of Denny, Robson and Irwin (1937 and 1939) has shown that powdered aluminium in very small percentage has a marked effect in preventing the development of silicosis following exposure to quartz dust, and Leroy Gardner (1944) has demonstrated beyond doubt that aluminium hydrate specifically inhibits fibrous reaction to quartz.

Before leaving the subject of respiratory disease reference should be made to the increased incidence of carcinoma of the lung already noted in the foundry worker; but it must be remembered that it is also found in those who work metal cold. Perhaps the higher number of cases occurring in foundry workers is due to a possible carcinogenic action of the fumes which sometimes occur in the foundry. It may be of interest to note that Argyle Campbell (1943) showed that mice exposed to a moderate cloud of iron oxide developed a significant rise in the occurrence of lung tumours compared with controls.

TABLE 8

X-RAY SURVEY OF WORKERS AT BUTTERLEY FOUNDRY

Total number examined = 60. Average age 29 years.

Part One. Showing number examined in different age groups.*

Age	under 20	21–30	31–40	41–50	51–60	60 plus	Total	Total showing dust changes
Fettlers ..	—	x 2 x	1	2	—	—	5	2
Moulders ..	2	xx 12	x 4	xx 3 x	x 5	x 5	31	8
Others	1	x 4	x 7	3	x 7	2	24	3
Total number examined ..	3	18	12	8	12	7	60	—
Total number showing dust changes in age groups ..	—	3	3	4	2	1	—	13

TABLE 9

X-RAY SURVEY OF WORKERS AT BUTTERLEY FOUNDRY

Total number examined = 60. Average age = 29 years.

Part Two. Showing length of exposure to dust.*

Length of exposure.	under 2 yrs.	3–5	6–10	11–15	15–20	21–25	26–30	over 30
Fettlers ..	—	1	—	—	—	x2x	—	—
Moulders ..	x 1	x 6	x 6	x 2	x 3	x x 4	1	xx 10
Others	x 1	5	xx 9	4	—	3	—	—
Total number showing dust changes according to length of exposure to dust	1	1	3	1	1	4	—	2
Total number examined ..	2	12	17	6	3	9	1	10

Skin Affections

Most of the skin cases were of the septic type, usually the result of mild staphylococcal infection, and the only inference which may be drawn from them is that probably the fine dust makes its way through a break in the continuity of the skin rather easily and carries the common bacteria with it.

Although no cases occurred in the period under review there is nevertheless a real risk of occupational dermatitis in foundry work. This generally shows itself in the form of the skin irritation seen in many other industries. In our experience dermatitis occurs most commonly amongst core makers in whom the irritation appears to be due to the oil used in the core sand, but other workers in the foundry are not immune and may be affected by sand alone. Another type of dermatitis is occasionally seen similar to that occurring in the coal miner and affecting the axillae and groins and other parts of the body where much friction and sweating take place. This is in effect an intertrigo.

* x indicates a worker showing dust changes in the lung on x-ray examination.

Rheumatic Disease

Until the causes of rheumatism are more definitely established it is not possible to give exact reasons for the high incidence of rheumatic disease in foundrymen; all that can be said is that the disease is very prevalent amongst workers exposed to sudden changes of temperature and strains on the muscles from heavy occupations.

Exposure to heat does not cause as much trouble as might be expected. Heat cramps are uncommon but not unknown; vague muscular pains may be due to salt depletion but Fantus' test for chlorides (War Office, 1943) in the urine gives an easy means of determining whether a fall below the dangerous excretion level of 3 g. in the twenty-four hours has taken place.

Accidents

It has already been seen that the Foundries had fewer accidents and much less lost time due to this cause than the Constructional Department. The accidents in the Foundries were not on the whole of a serious nature and surprisingly few burns caused trouble. Indeed, burns are much less common in foundry practice than might have been anticipated.

PREVENTIVE MEASURES

Pre-employment Examination

In view of the relatively high risk of disease occurring in the foundryman, a complete physical examination, including x-ray of the chest, should be carried out on all those entering the industry (*Lancet*, 1938, **2**, 629).

A history of respiratory disease is important, and taken in conjunction with x-ray findings may be enough to exclude an applicant from foundry work. Even in the absence of an anomalous x-ray one would hesitate to allow a person with a history of recurrent bronchitis to work in the foundry. X-ray evidence of tuberculosis, either active or quiescent, or of fibrosis of the lungs, is an absolute bar to foundry work. Those with infected tonsils or rhinitis, either hypertrophic or atrophic, do not as a rule do well in foundry work as they are liable to exacerbations of tonsillitis or rhinitis, often associated with sinusitis. They are better out of the foundry, but it is permissible to give them a trial.

Workers with perforated ear drums should be rejected, both on account of the risk of exacerbation of otitis media and also because they do not stand up well to the noisy conditions of machine moulding. People with previous history of skin disease or with actual dermatitis should be excluded, as also should those with very dry skins or those who tend to sweat unduly.

The value of the pre-employment examination cannot be rated too highly; it is of far more importance than any subsequent examination, for if it is

carried out conscientiously the greater number of those who are likely to break down under foundry conditions can be excluded. This is not to say that periodic examinations are not required, for it is agreed that they are desirable under any circumstances. Time does not allow of the periodic examination of employees in a large organization as frequently as one would wish, but we are aiming at a quarterly check on young persons up to 18 years of age with annual x-ray, and an examination, including x-ray, at five-year intervals for the older workers. Admittedly this is not ideal, but it should be sufficient to serve as a check on the dust hazard.

Building a New Foundry

Modern methods of construction and ventilation can greatly improve the conditions of the foundry. Noise and vibration can be reduced enormously, and a less vitiated atmosphere obtained. Proper cloak-room and washing facilities, including bathing facilities, are important and should receive as high a priority in consideration as the production part of the foundry.

The Existing Foundry

In the already existing foundry, as in other shops, the attention of the management should be directed to defects in lighting and ventilation; but heating, floors, and house-keeping are most difficult problems. In winter weather the shop is liable to be cold in the morning before casting begins and it is difficult to see how this can be overcome without an air conditioning system.

Concrete floors are desirable as they are comparatively easy to keep clean, but they are satisfactory only in the case of the mechanized unit where pouring takes place at a definite point and there is no great risk of spilling metal on to the floor with fragmentation of the concrete. It is quite otherwise, however, in the foundry dealing with large castings or where pouring is done with the boxes on the floor, although concrete walk-ways may be possible. Good house-keeping is easier where there is a concrete floor but is by no means so easy in the foundry as in some other shops.

Baths

It has been shown that rheumatism takes a high place amongst the hazards of the foundry, and Osgood (1932) after emphasizing the importance of proper environmental conditions both at work and away from it in the prevention of this disease, stresses the necessity for providing shower baths at work. The provision of baths is no less necessary in order to reduce the high incidence of skin conditions, and there is no doubt that changing rooms and shower baths on the principle of pit-head baths are urgently needed in the foundry industry. Baths are not sufficient in themselves and frequent change and washing of working clothes are required in order to control skin conditions.

Bathing facilities will not only improve the health of the worker in the foundry in an overt manner, but also indirectly by enabling him to pass to and from his work as clean as any of his companions in less dirty trades and by so doing increase his self-respect. Drinking water should be provided at suitable points and is best supplied by bubbler fountains. Salt tablets should be available if necessary for those exposed to excessive heat so that the risk of heat cramps may be minimized.

Protective Equipment

Hand leathers should be supplied to those handling rough castings, and all foundry workers should wear properly protected boots. Leather spats or spat leathers with strap fastenings should also be used to protect against splashes of molten metal. Aprons should be of asbestos or of material rendered fireproof by chemical means.

A proper eye-protective appliance must, of course, be provided for those exposed to the glare of furnaces and molten metal, and grinders require goggles to prevent injury to the eyes from flying particles of metal and dust. Respirators are also needed for grinders, and they should also be worn by those engaged on dusty processes which cannot be kept properly under control such as the repair of cupola linings.

Dust

The main specific health risk of the iron foundry is the inhalation of free silica, and the substitution of an innocuous material for a harmful one is the best way in which to deal with any hazard. The use of olivine which is a mineral composed of magnesium and ferrous orthosilicate ($MgFe_2SiO_4$) and which recent work (King and Rogers, 1945) has shown to have no fibrosis-forming effect on the lungs, has been suggested (Goldschmidt, 1938) as a practicable substitute for the sand used for the body of the moulds. Whether this substance proves to be technically satisfactory remains to be seen, but there is no possible justification for the use of a silica parting powder when equally effective non-siliceous powders are available; and this is largely true also of silica paint. As long as a sand containing free silica is in use in the foundry, dust control will remain vital, the principal danger points being the knock-out, stripping, fettling and grinding operations, including rumbling and blasting by means of wheelabrator, sand-blasting or other methods.

The regulations regarding sand-blasting render the process reasonably safe and the enclosed types of wheelabrator or rumbler with exhaust extraction are also satisfactory, provided that the extraction system works efficiently. Grinding carried out in accordance with the regulations also meets the case, but the knock-out and fettling operations are not governed by regulations and require special consideration. In the case of the knock-out the difficulty can be largely overcome by drawing the dust downwards through the grating by artificial means

(see fig. 10) while the fettling of small castings can be done in a similar manner on a mild steel bench constructed on the grating principle and fitted with an exhaust system.

The larger casting presents special difficulties although a pneumatic chisel fitted with a small hood and flexible duct has been tried with encouraging results. Tests made in the United States of America suggest that there is no risk of inhalation of dust in the operation of hydro-blasting, and in a foundry in this country where the plant is in use the atmosphere certainly seemed very clear. Meanwhile the fettler carrying out this kind of work should wear suitable protective clothing (see fig. 13).

Although the greater amount of dust and fume in the atmosphere of the mechanized foundry can be kept under control by suitable methods of exhaust ventilation, installation of the hydro-blast system of cleaning castings should be carefully considered in all large foundries. Increased mechanization also has the merit that it reduces the amount of weight lifting, for in far too many foundries weights greatly in excess of the generally accepted standards are lifted all day and every day.

Acknowledgments

Our thanks are due to Mr. G. Walker, manager of the foundries of the Butterley Company, Ltd., for much help in the description of the technical processes; to Mr. John Gardom for the drawings reproduced in figs. 1 and 2; and to Messrs. Pneulec, Limited, for the photographs illustrating foundry methods. We must also thank Miss Pullon, Secretary of the Medical Department, for her invaluable assistance throughout the preparation of this paper.

Summary

A brief description is given of modern ironfounding methods.

Environmental studies were carried out in two foundries employing over 200 workers. These studies included a survey of ventilation and heating, and the dust hazard.

To assess the dust hazard in a foundry knowledge is required of (*a*) the dust concentration in the work atmosphere, (*b*) the duration of work spells, (*c*) the chemical composition of inhaled dust, and (*d*) its particle-size frequency.

In this survey it is shown that fettlers of medium and large castings have the dustiest occupation in the foundry. Chemical analysis shows that the dust here consists largely of silica particles. In the foundries under consideration it is estimated that the silica hazard of the fettler of large castings is fifty times that of a worker in the general body of the foundry; medium fettling represents a nine times greater hazard; and pneumatic mould-filling and shaking-out no more than five times.

Workers in the core shop are exposed to a minimal dust hazard because of the nature of the material used.

Routine control of atmospheric pollution in a foundry is essential. The simplest way of doing this is by mass concentration estimations of airborne dust at breathing height.

Sickness and accident rates among the foundry workers were compared with those in another department (constructional).

The number of cases of respiratory disease in the foundries was less, although the average number of days lost per case was higher. Sixty foundrymen had chest x-ray examination. While 21 per cent. of these showed some evidence of ' dust change ' in the lung (40 per cent. of fettlers being affected), no case of silicosis was found, even in its early stages.

Affections of the skin were greater in the 200 foundry than in the constructional department, most of them being mild staphylococcal infections. Dermatitis in the foundry occurs most commonly among core-makers.

The incidence of rheumatic disease was greater among the foundrymen than among the workers in the constructional department. No definite reasons can be given for this.

Among foundrymen heat cramps are uncommon but not unknown.

Accidents causing injury were fewer and caused much less lost time in the foundries. Burns are less common in foundry practice than was anticipated.

Preventive measures against accident and ill-health are (*a*) pre-employment medical examination, including chest x-ray; (*b*) improvement of ventilation by modern construction methods; (*c*) proper cloak-room, washing and bathing facilities; (*d*) attention to floors; (*e*) by adequate protective equipment for the individual worker; and (*f*) prevention of fumes and dust by alteration in materials where possible, by increasing mechanized methods of production, e.g. introducing the hydro-blast system, and by good general house-keeping.

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TRICHLORETHYLENE: ABSORPTION, ELIMINATION AND METABOLISM

BY

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In a recent paper from this laboratory (Stewart and Witts, 1944) the clinical picture of chronic carbon tetrachloride intoxication was described. As a result of this experience it seemed desirable to devise quantitative methods for measurement of the degree of exposure to chloro-compounds of this type. Such methods would be of value not only in industrial medicine but also in therapeutics, as, for example, in studying the action and side effects of chloro-compounds used as anaesthetics and parasiticides. Subsequently a paper was published describing the estimation of trichlorethylene, chloroform and carbon tetrachloride in the blood in man (Habgood and Powell, 1945). The present paper, which is the third in the series, is a detailed study of the absorption and elimination of trichlorethylene. Trichlorethylene was chosen because we were able to study human subjects to whom it was given as an anaesthetic. The results have nevertheless a wider application, since trichlorethylene (Trilene, Westrosol, Crawshawpol) is used in industry in large quantities as a degreaser and a dry cleaning agent. Compared with tetrachlorethane and carbon tetrachloride, its toxicity is low (Hamilton, 1943) and some of the ill-effects which it is reported to produce in the nervous system can possibly be attributed to impurities, chiefly dichloracetylene, in the commercial preparation (Hunter, 1944).

Although trichlorethylene was selected for study largely on the grounds of convenience and accessibility of cases, the results we have obtained have a special interest in view of the curious chemical reaction involved in the metabolism of trichlorethylene. Barrett and Johnston (1939) have found that 5–8 per cent. of the trichlorethylene absorbed by dogs during anaesthesia could be recovered from the urine as trichloracetic acid. The urine of human subjects who had been exposed to trichlorethylene vapour also gave chemical reactions indicative of the presence of trichloracetic acid, although the latter was not actually isolated (Barrett, Cunningham and Johnston, 1939). In the following investigation, trichlorethylene concentrations have been determined in blood during anaesthesia, and an attempt has been made to follow the elimination of trichlorethylene and its metabolite by analyses of blood, urine and expired air. We have been able to demonstrate that in man also trichlorethylene is in part metabolized to trichloracetic acid. This phenomenon is of considerable chemical and toxicological interest. It is also probable that it could be applied as the basis of a simple urinary test for undue exposure to trichlorethylene in industry.

Methods

Blood

For the determination of trichlorethylene in blood (Habgood and Powell, 1945), the chlorhydrocarbon was first removed by steam distillation. The aqueous distillate was then extracted with toluene, and an aliquot of the toluene extract treated with pyridine and alkali. An orange-red colour was thus developed, the intensity of which was proportional to the amount of trichlorethylene present. Analyses of blood specimens, obtained at intervals after the anaesthetic was stopped, indicated the rate of elimination of trichlorethylene from the blood stream.

When blood obtained 24 hours, and later, after anaesthesia was treated in the above manner, the steam distillate gave a faint but definite purplish-pink colour, quite different from the orange red given by trichlorethylene. Urine collected at this time gave a similar reaction. The same purplish-pink colour was obtained on heating trichloracetic acid or chloroform with pyridine, alkali and toluene. The substance present in the blood after trichlorethylene anaesthesia could not, however, be removed by a current of air at room temperature (*v.i.*). This observation, together with the findings of Barrett, Cunningham and Johnston, suggested that it was trichloracetic acid or some closely related substance. While an attempt was being made to isolate trichloracetic acid or a derivative from urine (*v.i.*), the following procedure was adopted for the simultaneous determination of trichlorethylene and trichloracetic acid in blood.

The trichlorethylene was first removed by passing a stream of air through blood diluted with 7 times its volume of water in the apparatus shown in fig. 1; 5–10 ml. of blood

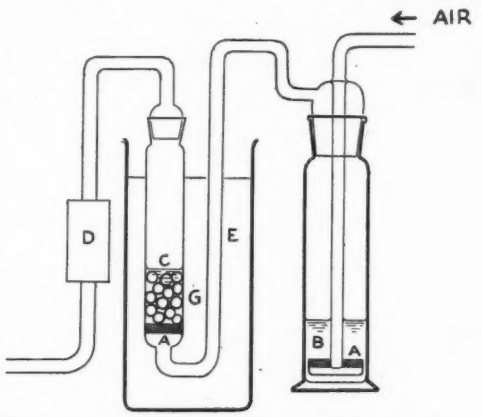


FIG 1.—Apparatus for estimating trichlorethylene and trichloracetic acid in blood.

A. Sintered glass plate. B. Blood. C. Toluene. D. Flowmeter. E. Ice water. G. Glass beads.

were used for the analysis, and a few drops of tri-*n*-butyl citrate added to prevent excessive frothing. This substance was shown not to interfere with the final colour reaction. Air was then drawn through for 30 minutes at 100 ml./minute, and for 30 minutes at 200 ml./minute, the trichlorethylene thus removed being absorbed in 2–5 ml. of toluene.

For the colorimetric analysis, 1 ml. of the toluene solution was added to 10 ml. of pyridine and 5 ml. of 20 per cent. sodium hydroxide. The mixture was then heated and the resulting colour measured as before.

For the determination of trichloracetic acid, or trichloracetate, 8 ml. of the diluted blood from which trichlorethylene had been removed were treated with 1 ml. of 10 per cent. sodium tungstate and 1 ml. of 2/3-*N*-sulphuric acid; 5 ml. of the protein-free filtrate were then added to a mixture of 10 ml. of pyridine, 1·2 ml. of saturated aqueous sodium hydroxide and 1 ml. of toluene. On heating at 100° C. for 5 minutes, a purplish-pink colour developed, and this was measured as before.

Trichlorethylene and trichloracetic acid added to the same blood sample could be recovered in this way with an accuracy of ±5 per cent.

Expired Air

Trichlorethylene in expired air was determined after absorption in toluene. In carrying out this analysis, it is essential that the absorption apparatus should have a low resistance to normal breathing. Absorption bottles with sintered glass discs were found to be too resistant, so bottles were made with inlet tubes terminating in perforated flattened bulbs. It was found that 92 per cent. absorption of trichlorethylene from air containing up to 3·5 mg./litre could be effected by passage through three absorption bottles of the above type connected in parallel, at a total rate of 1 litre/minute. The patient breathed into a mask which was fitted with an inspiratory and expiratory valve; from the latter a breathing tube led to the absorption train. A side branch in this tube, which permitted the greater part of the expired gases to escape into the atmosphere, was controlled by a screw clip. The latter was adjusted so that roughly one-eighth of the expired air passed through the bottles, each of which contained 30 ml. of toluene. The tube from mask to bottles was of polythene, which does not absorb chlorhydrocarbons as readily as does rubber. After passing through the absorbers, the air was collected in a Haldane bag and its volume subsequently measured. The volume of air passing through the absorbers varied between 15 and 40 litres—depending on the amount of trichlorethylene expected.

Urine

No attempt was made to determine trichlorethylene in urine—the amount excreted by this route is probably very small and would require troublesome precautions for accurate measurement. For the determination of trichloracetic acid in urine, it was generally convenient to add 0·5 or 1 ml. of urine to 10 ml. of pyridine, 5 ml. of 20 per cent. sodium hydroxide and 1 ml. of toluene. When the trichloracetic acid concentration is very low, i.e. less than 2 mg./100 ml., 5 ml. of urine can be used for the estimation, together with 10 ml. of pyridine, 1·2 ml. of saturated aqueous sodium hydroxide and 1 ml. of toluene. The colour interference produced by urinary pigments is negligible when 1 ml. of urine is taken for the analysis, and very slight with 5 ml. of urine.

Proof of the Presence of Trichloracetic Acid in Urine after Trichlorethylene Anaesthesia

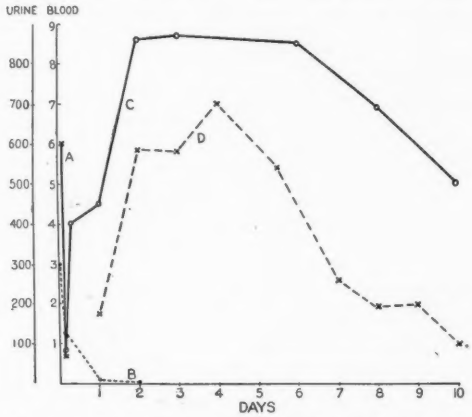
Eight litres of urine, collected from three patients during the period 24–72 hours after anaesthesia with trichlorethylene, were made strongly acid with hydrochloric acid, and extracted four times with 1 litre of ether. After evaporating to a bulk of 100 ml., the highly pigmented ether extract was boiled with charcoal to remove the colour. At this stage a 20 per cent. loss of trichloracetic acid occurred. This was shown by adding a small quantity of ether extract before and after charcoal treatment to a measured volume of water, the ether being blown off and an aliquot of the residue taken for analysis with pyridine and alkali. To half of the colourless ether solution of trichloracetic acid the calculated amount of piperazine was added. After stirring thoroughly and adding a large excess of ether, the white precipitate formed was filtered off, washed with ether and crystallized from glacial acetic acid. The product thus obtained melted sharply at 121·0° C., and no depression of melting-point was observed after mixing with an authentic specimen of the piperazinium salt of trichloracetic acid.

The remaining half of the ethereal solution was extracted with the calculated amount of dilute sodium hydroxide necessary to form the sodium salt of trichloracetic acid. The alkali extract was then evaporated to dryness. The resulting white solid considered to be mainly sodium trichloracetate was heated with aniline and sodium hydroxide, when the characteristic carbylamine smell was detected. This was proof of the presence of chloroform formed by decomposition of the trichloracetate.

Results

Trichlorethylene concentrations in venous blood have been determined in 12 patients during anaesthesia, blood samples being collected after the patient had received 1·5–2·5 volumes per cent. trichlorethylene from an Oxford vaporizer for at least half an hour. The concentrations found varied between 6·5 and 12·5 mg./100 ml. Arterial and venous blood specimens obtained at the same time from a patient who had received an average of 2 per cent. trichlorethylene for an hour contained 9·8 and 9·9 mg./100 ml. respectively. In five cases, blood samples were collected during a short period of deep anaesthesia associated with rapid shallow breathing, and here the trichlorethylene concentrations were in the region of 10·0–12·5 mg./100 ml. In another patient with slight hyperpnoea, from whom both arterial and venous blood specimens were obtained, it is of interest to note that, although the level in venous blood was only 6·5 mg./100 ml., the arterial concentration was 10·8 mg./100 ml.

Results obtained by analysis of blood, urine and expired air from two patients are given in fig. 2. Less



Patient I.—2·5–3 per cent. trichlorethylene for 1 hour 20 minutes.

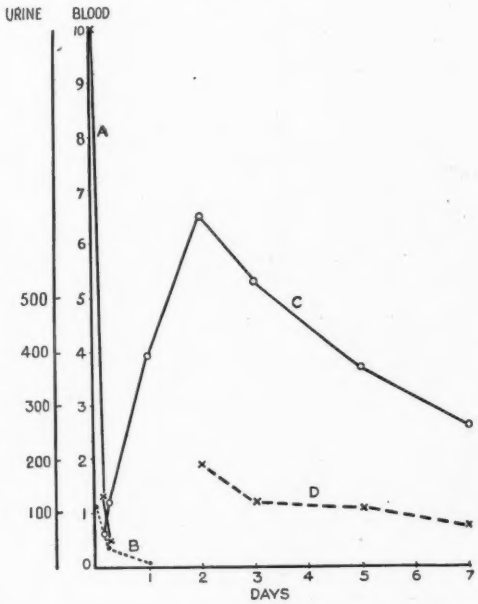


FIG. 2.

Patient II.—1·5–2 per cent. trichlorethylene for 20 minutes.

A. Trichlorethylene concentrations in blood (mg/100 ml.).
B. Trichlorethylene concentrations in expired air (mg./litre).
C. Trichloracetic acid concentrations in blood (mg./100 ml.).
D. Trichloracetic acid in urine. Daily excretion (mg.).

complete data from two other cases, in which urine collection was not satisfactory, are summarized in Table 1.

It was found that trichlorethylene disappeared very rapidly from the blood, the concentration falling below 1·0 mg. per cent. in 3 hours and to 0·1 mg. per cent. in 24 hours. The amount of trichlorethylene in the expired air showed the same steep decline. Meanwhile a non-volatile substance giving a pink colour with pyridine and alkali, similar to that given by trichloracetic acid, appeared in blood and urine. The concentration of this compound, which has been expressed in terms of trichloracetic acid (*v.i.*), reaches a maximum in about two days and seems to depend roughly on the amount of trichlorethylene inhaled. Thus, in the first patient, where 2·5–3 per cent. trichlorethylene was administered for nearly 1½ hours, a maximum concentration of 8·6 mg./100 ml. was reached, and in spite of a high urinary excretion this level was maintained for four days, after which it slowly decreased. In three other cases where considerably less trichlorethylene was given, maximum concentrations of trichloracetic acid were lower, in the region of 5–6 mg./100 ml. Here again the trichloracetic acid concentration decreased very slowly, being still rather more than 50 per cent. of the maximum concentration six days after this was attained.

TABLE 1

BLOOD TRICHLORETHYLENE AND TRICHLORACETIC ACID CONCENTRATIONS AFTER ANAESTHESIA

		Trichlorethylene (mg./100 ml. blood)	Trichloracetic acid (mg./100 ml. blood)
	End of anaesthesia Expired air 2·8 mg./litre.	8·1	—
Patient III 4 per cent. for 25 mins.	5 hours 24 „ Expired air 0·035 mg./litre.	0·27 0·1	0·3 4·5
	4 days 6 „ 8 „ 12 „	— — — —	3·0 2·5 2·1 2·0
	End of anaesthesia	8·1	0·3
Patient IV 1–1½ per cent for 1 hour	3 hours 6 „ 24 „ 2 days 5 „ 8 „	0·7 0·3 0·1 — — —	0·5 0·9 4·8 5·5 5·0 3·5

The daily excretion of trichloracetic acid in the urine ran roughly parallel with the blood concentration. In patient I, the average excretion during the first six days was 500 mg. This had fallen to 200 mg. on the eighth day and to 100 mg. on the tenth day. The total amount excreted during the 10-day period was 3·7 g. In the other three patients, who received much less trichlorethylene, the amount of trichloracetic acid excreted was correspondingly smaller. In patient II, the total amount in the urine during the 7-day period following anaesthesia was only 0·5 g. In patients III and IV, the total amount excreted during the same period was approximately 1 g.

Discussion

Van Dessel (1923) has found the concentration of chloroform in the blood of human subjects during anaesthesia to vary between 15 and 25 mg./100 ml. Although the anaesthetic potency of chloroform and trichlorethylene, as derived from the atmospheric concentrations causing deep narcosis in animals in 30 minutes (Haggard and Henderson, 1943), is found to be about equal, the anaesthetic concentrations obtained here for trichlorethylene are markedly lower than those given for chloroform. The above definition of anaesthetic potency does not, however, take into consideration the relative solubilities of chloroform and trichlorethylene in blood, which is obviously of great relevance in this connexion. It is interesting to note that the rapid shallow breathing observed in several of the patients during anaesthesia was associated with a blood trichlorethylene concentration of about 10 mg./100 ml. With regard to the elimination of trichlorethylene from the body, it is evident from the analyses of expired air that trichlorethylene, as such, virtually ceases to be excreted via the lungs in 48 hours. The rate of disappearance from the blood stream is comparable with that found for chloroform (Nicloux, 1906), falling to about 10 per cent. of the initial value in 3 hours, and to 5 per cent. in 6 hours.

It has also been shown here that a non-volatile organic chloro-compound is present in blood and urine for relatively long periods after anaesthesia. This compound gives a colour with pyridine and alkali indistinguishable from that given by trichloracetic acid. Taking into consideration the isolation of a derivative of trichloracetic acid from urine, and of a sodium salt which readily gives a carbylamine reaction with aniline and sodium hydroxide, it seems that trichloracetic acid does appear in blood and urine as a product of metabolism of trichlorethylene. At the *p*H of blood, trichloracetic acid would obviously exist as a salt. It would be rather difficult to prove that trichloracetic acid is the only metabolic product, although this appears to be likely. The chloro-compound in urine cannot be extracted with ether from an *alkaline* solution, but only if the urine is made *acid*, which indicates that it is essentially completely acidic in character. It seems very unlikely that a mixture of chlorinated organic acids is present, since a pure specimen of the piperazinium salt of trichloracetic acid was obtained from the ether extract of urine without difficulty.

In all the cases studied, the trichloracetic concentration in blood increases to a maximum about 48 hours after anaesthesia, and then decreases very slowly. In patient I, the maximum concentration is maintained for several days. It seems probable that trichlorethylene is not metabolized in the blood stream, and to explain the relatively slow appearance of trichloracetic acid in the circulation it is tentatively suggested that the level is built up by diffusion from some organ where fixation and metabolism of trichlorethylene has taken place.

It is possible that routine blood and urine tests for trichloracetic acid might be used to control harmful exposure to trichlorethylene in industry. The excretion of trichloracetic acid is very slow, and a cumulative effect might be produced by small but frequent exposures to trichlorethylene vapour. There are no experimental data on this point, but such data could easily be obtained. At the same time, it must be remembered that a similar colour reaction is given by chloroform and chloral, which may have been taken medicinally.

With regard to the toxicity of salts of trichloracetic acid, it is interesting to note that Liebreich (1869) injected sodium trichloracetate intravenously into human subjects, with production of slight anaesthesia. We have found that intravenous injection of 400 mg. of sodium trichloracetate produced a slight decrease of blood pressure in a cat previously anaesthetized with phenobarbitone. A blood sample taken 20 minutes after the injection contained 47 mg. of trichloracetate per 100 ml. Injection of 320 mg. of sodium trichloracetate into an anaesthetized rabbit also produced little effect, the blood concentration being 33 mg./100 ml. 15 minutes after the injection. This would suggest that the toxicity of trichloracetate at the concentrations found in the blood after trichlorethylene anaesthesia is negligible.

Smaller doses have proved equally harmless in man. We have made several observations on the rate of excretion of sodium trichloracetate by human subjects after intravenous injection of 2–3 g. of the salt. Blood samples were collected at intervals over a period of 7–10 days after the injection. The total urinary output

was also collected and analysed over the same period. It was found that in the first 36 hours after the injection the blood concentration had fallen to 50 per cent. of the initial value. This fall was partly accounted for by diffusion into the tissues, since only 15–20 per cent. of the total trichloracetate injected had appeared in the urine during this period. After this, the blood concentration decreased very slowly, at a rate comparable with that found in the four patients after trichlorethylene anaesthesia. Seven days after the trichloracetate was injected, blood concentrations of 2–4 mg./100 ml. were still found.

The mechanism of conversion of trichlorethylene into trichloracetic acid, with the possibility of toxic intermediary compounds, remains a matter for conjecture. The conversion implies either a migration of chlorine from one carbon atom to the other, or an addition of hydrochloric acid to the trichlorethylene molecule. It is interesting to note that chloral may be produced from trichlorethylene *in vitro* via the unstable trichlorethylene oxide $CCl_2 \diagdown\!\!\diagup CHCl$ (British patent 523,555 ; 1940), and trichloracetic acid might be formed in the same way. It would be remarkable if this channel of metabolism could be followed with so little evidence of ill-effect. It is true that a number of cases has recently been reported in which cranial nerve palsies and encephalitis have followed the use of trichlorethylene as an anaesthetic, but these all appear to have occurred under circumstances in which dichloracetylene might have been expected to be produced through passage of the trichlorethylene through the soda lime used for absorption of carbon dioxide (McAuley, 1943; Carden, 1944; Humphrey and McClelland, 1944). There is no evidence that the trichloracetate produced in the metabolism of trichlorethylene or its precursors are toxic, but the possibility seems worthy of further exploration.

Summary

Trichlorethylene concentrations in the blood of 12 patients during anaesthesia ranged between 6·5 and 12·5 mg./100 ml.

Part of the trichlorethylene absorbed is converted into trichloracetic acid, and derivatives of this compound have been prepared from urine.

The elimination of trichlorethylene and its metabolite from the body has been studied by analysis of blood, urine and expired air in four patients after anaesthesia.

Intravenous injections of sodium trichloracetate into animals and human subjects have produced no ill-effects; this salt is excreted rather slowly after intravenous injection.

The possible relation of these findings to the toxic hazards of trichlorethylene and the detection of undue exposure in industry are briefly discussed.

Acknowledgments

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ADDED INFECTION IN INDUSTRIAL WOUNDS

BY

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Sepsis is a complication of industrial wounds that leads to much loss of working time as well as to considerable disability, and the reduction of its incidence is a matter of some importance. In the wider field of general wound infection, it has been found that a proportion of the cases of disabling and fatal sepsis is due to microbes added to the wounds during their treatment. These microbes may be added by the patients themselves or by others, but in both cases the greatest opportunities for their addition occur when the wounds are exposed for treatment and dressing, especially in places where a number of wounds, some of them already infected, are being treated together. Added infection of this kind, traceable to faults in the aseptic routine of dressing, is known to occur in hospital wards and out-patient departments (see 'Medical Research Council War Memoranda' Nos. 6, 1942, and 11, 1944). In the light of the recorded prevalence of sepsis in industrial wounds (e.g. 'Annual Report of Chief Inspector of Factories,' 1942), it is clearly important to know how far factory surgeries resemble hospital departments in this respect.

Methods and Terms Used

Surveys of wounds presented to hospital out-patient departments have shown that sepsis is associated, in all but 5–10 per cent. of cases, with infection by *Staph. aureus*, *Str. pyogenes*, or both (Williams and Miles, 1945). We have accordingly restricted our survey of industrial wounds to these two species, together with any other bacteria, like coliform organisms, which grew easily on the media used to reveal the two pyogenic cocci.

Our bacteriological methods and the definitions of the descriptive terms used are given more fully elsewhere (Williams and Miles, *loc. cit.*). Briefly, we have sampled both wound and skin with moist swabs. The skin swabs were cultivated aerobically, and the wound swabs both aerobically and anaerobically, on blood agar, though in the preliminary survey recorded below the anaerobic culture was omitted. The wound swabs were also inoculated into cooked meat medium which was sub-cultured, after two days' incubation, to reveal microbes initially present in small numbers.

We have confined the term *Staphylococcus aureus* to coagulase-positive staphylococci and have designated as 'micrococci' all other gram-positive cocci that were not streptococci. *Streptococcus pyogenes* refers to beta-haemolytic streptococci belonging to Lancefield's Group A, and 'coliform organisms' to gram-negative bacilli, mostly of supposed intestinal origin—e.g. *Bact. coli*, *Bact. aerogenes*, *Pseudomonas*, *Proteus*, etc.

Organisms isolated within six hours of wounding are described as *contaminating*, rather than *infecting*, the wound; infection cannot be presumed to be present within this period since the bacteria have not had time to establish themselves and the tissue response to the invasion has not developed. The presence of *Staph. aureus*, *Str. pyogenes* or coliform organisms, in a wound more than six hours old has been regarded as indicative of *infection*, regardless of the clinical state of the wound. Wounds showing infection without any clinical changes are said to be silently infected; wounds with the signs of inflammation—suppuration, redness and swelling—are described as *septic*; those with some redness or swelling without frank discharge are described as *inflamed*. The wounds were regarded as healed when they were closed, dry and free from all except very small areas of scab.

PRELIMINARY SURVEY: GROSS INFECTION RATES

As a preliminary we surveyed 531 open wounds as they were presented at the surgery in 19 factories of different sizes and with varying first-aid facilities. Most of the wounds sampled were cuts, but some grazes, burns, puncture wounds, boils, septic eyes and septic rashes, were also included. Of the 531 lesions swabbed, 255 (48·0 per cent.) were infected or contaminated with *Staph. aureus*, *Str. pyogenes* or both (Table 1). About half the infected wounds were septic; the rest were silently infected. If the freshly inflicted wounds, 19 per cent. of which were contaminated with *Staph. aureus*, are excluded, the infection rate is 57·3 per cent. These sepsis and infection rates are not reliable as measures of the risk to initially clean wounds treated in the surgery. They are too high because, if a steady rate of wounding is postulated, on any one day the infected patients include a considerable proportion of all the persons wounded during the preceding two weeks whose attendance has been prolonged by sepsis and infection of the wound. Thus in our survey the infection rate increased with the age of the wounds (Table 2): among wounds 1–4 days old it was 48 per cent.; in those 5–14 days old it was 57 per cent.; and it reached 84 per cent. in those more than 14 days old. *Str. pyogenes* was found more commonly in older wounds than in fresh or recent ones. The uninfected, on the other hand, who tend more rapidly to reach a stage at which attendance at the surgery is unnecessary, will in the main comprise only those injured within the past few days. For these reasons the gross rates probably over-estimate the prevalence of infection in wounds of a given age.

The preliminary survey established the fact that

TABLE 1

GROSS INFECTION RATES IN FACTORY SURGERIES

Factory	No. of wounds swabbed	Percentage of all wounds infected or contaminated with—			Total percentage infected or contaminated with *Staph. aureus* or *Str. pyogenes*
		Staph. aureus alone	*Str. pyogenes* alone	*Staph. aureus* and *Str. pyogenes* together	
All	531	38·7	1·6	7·7	48·0
All (fresh cuts excluded)	397	45·0	2·3	10·0	57·3
Factories with 25 or more wounds sampled:					
1	47	32	0	4	36
2	28	39	0	0	39
3	40	25	8	8	41
4	27	26	0	22	48
5	56	48	0	2	50
6	31	52	0	3	55
7	25	36	0	24	60
8	26	54	0	8	62
9	63	41	8	17	66
10	26	46	8	15	69

TABLE 2

INFECTION RATE AND AGE OF WOUND

Age of wound	No. of wounds	Percentage of wounds infected or contaminated with—			Total percentage infected or contaminated with *Staph. aureus* or *Str. pyogenes*
		Staph. aureus alone	*Str. pyogenes* alone	*Staph. aureus* and *Str. pyogenes* together	
<6 hours	134	19	0	1	20
1–4 days	167	41	3	4	48
5–14 days	98	45	1	11	57
>14 days	26	30	15	39	84
Not noted	34	50	0	3	53

Note.—Boils, burns and septic rashes are not included in this table.

wounds treated in factory surgeries are infected with the same bacterial species as the larger wounds previously studied in hospital. It gave no information, however, about the influence on infection of the method of wound treatment, the nature of the injury, etc.; the crude rate obtained is certainly affected by the age distribution of the wounds sampled, the readiness with which the workers attend the surgery for the treatment of wounds that have not become septic, and the sort of injuries that predominate in the factory, as well as the form of treatment applied in the surgery.

We have attempted to determine the influence of the dressing technique on the incidence of infection by making a detailed survey in two factories where the type of work done, the size of the factory and of the surgery, and the antiseptic treatments adopted, were very similar, but where there was a notable difference in the aseptic wound dressing technique.

DETAILED COMPARISON IN TWO FACTORIES

Surgery Routines

The two factories (A and B) were both engaged in light engineering. They had well-established medical departments staffed almost entirely by state registered nurses. In both, wounds and 'medical' conditions were treated in the same room; at A there were separate surgeries for men and women, but at the time of our survey at B all patients there were treated in one room, owing to rebuilding operations. At A there were some 65 first-aid boxes distributed throughout the works, each supervised by a worker with some training in first aid, and 32 per cent. of the patients in our survey had had previous treatment at a box immediately before coming to the surgery. There were no boxes in the shops at B.

The general treatment of the wounds was similar: aqueous acriflavine was used for the majority of clean cuts and for many that showed signs of sepsis. At A, gentian violet was often applied to grazes and obviously soiled wounds. Ichthyol ointment, and at B merthiolate, were used for many septic cuts. Greater use was made at A than at B of adhesive

plaster 'butterfly' strips to maintain apposition of gaping skin edges, and of immobilization with metal splints and protection with thick linen fingerstalls.

At A, all dressing materials were sterilized; at B they were used as supplied by the manufacturer. A few tests have shown that such dressings are unlikely to contain more than a few aerobic spore-bearing bacilli and other non-pathogenic organisms.

Wounds were usually redressed daily, or more often if the dressing became badly soiled or soaked in oil.

The routine for performing the dressings was notably different in the two factories:

For redressings at *Factory A*, the nurse cut through the outer bandage, removed it with her fingers and discarded it into a bin. Forceps, kept in a jar of lysol on the trolley, were used for the remaining manipulations. The nurse removed the inner dressings, dipped a piece of gauze into a bowl of dettol and used it to clean the wound; she then applied another piece of gauze, moistened in antiseptic (usually acriflavine) to the wound as a dressing. The nurse discarded the forceps and applied the bandage by hand. She then recorded the treatment, tidied the top of the trolley, washed her hands and took the forceps to the sterilizer.

With fresh injuries, the skin round the wound and then the wound itself were cleaned, each with a piece of gauze moistened in dettol and held in forceps. If the injured hand was very dirty, the wound was covered with a bandage and the patient instructed to wash the rest of the hand at a basin. The subsequent procedure was as for a redressing.

The routine was followed for the majority of cases. Occasionally forceps were not used and occasionally hand-washing was omitted, but these lapses occurred with any frequency only when the surgery was very busy.

Small pieces of swarf embedded in the tissues were extracted with needles kept in spirit and removed from it with forceps.

At *Factory B*, the nurses were again fairly consistent in their methods but instruments were not used and the nurses' hands were washed only when obviously soiled. For redressings the nurse cut the bandage with scissors kept on the top of the trolley and then removed the dressings with her fingers. Gauze strips, selected by hand from a glass jar and dipped into the antiseptic, were used to clean the wound and were then discarded into an open kidney dish on the top of the trolley. A fresh piece of gauze, also dipped in the antiseptic, was used for the dressing, and the wound was then firmly bandaged. The nurse recorded the treatment and proceeded to the next patient.

With fresh injuries, the wound and the surrounding skin were washed with a piece of cotton-wool moistened in warm but not sterile water, which was kept in an open bowl on the trolley-top and changed three or four times during the morning. Only the skin immediately adjacent to the wound was cleaned, regardless of the state of the rest of the part. The procedure was then as for a redressing.

Embedded swarf was removed with needles kept in a jar of spirit. After use they were usually rinsed in the warm water used for cleaning wounds, dried on a piece of cotton-wool and replaced in the spirit.

Selection of Cases

The investigation at Factory A lasted, with one month's interval, from August to December, 1943, and that at B from February to March, 1944. The material of the investigation consisted of wounds presented to the surgery within 6 hours of infliction and between the hours of 9.0 a.m. and 12 noon, during which time one of us was present in the surgery. At B we know that no wound was excluded because it was too trivial; the same holds for the great majority at A, though a few cases were selected and swabbed by the nursing staff in the afternoons, and here we cannot be sure that the very slight wounds were included. Serious wounds needing hospital treatment were not included. The wounds were swabbed again at each redressing and notes on the clinical state were made by one of us.

The majority of the injuries studied were very small cuts of the hand, but cuts on other parts of the body, as well as a few abrasions, burns and puncture wounds, were included (Tables 3 and 4).

TABLE 3

NATURE OF THE WOUNDS STUDIED

Nature of wound	Factory A 285 cases per cent.	Factory B 187 cases per cent.	Total 472 cases per cent.
Cuts	73·7	70·5	72·5
Abrasions	11·5	23·5	16·4
Burns	0·3	0·5	0·3
Puncture wounds	3·0	4·5	3·6
Not noted	11·5	1·0	7·2

TABLE 4

SITE OF WOUNDS

Site of wound	Factory A 285 cases per cent.	Factory B 187 cases per cent.	Total 472 cases per cent.
Hand, wrist and forearm	83·5	89·9	86·1
Elbow	1·7	1·1	1·4
Foot	1·4	0·5	1·1
Leg	3·5	1·6	2·7
Head	4·6	3·7	4·3
Not noted	5·3	3·2	4·4

Two hundred and eighty-five cases were studied at A and 187 at B but, owing to the fact that the patients frequently failed to re-attend, by no means all were observed until the wounds were healed (Table 5). We have divided the wounds into four groups according to the completeness of investigation. Group I wounds were followed until they were fully healed; Group II had more than three follow-up swabs taken, but were not followed until healed; Group III had three or fewer follow-up swabs and were not followed until healed; and

Group IV were not seen after the first attendance. It will be noted that owing to default in attendance of the patients there was, from the point of view of the investigation, a very considerable wastage of the cases admitted.

TABLE 5

NUMBERS OF CASES IN GROUPS I–IV

Group	Factory A	Factory B
I—Followed until healed ..	88	48
II—4 or more follow-up swabs	39 } 127	25 } 73
III—Less than 4 follow-up swabs	82	51
IV—Not seen after first attendance	76	63
Total admitted to study ..	285	187

Results

Incidence of Infection and Sepsis. Table 6 shows the incidence of infection and sepsis in the two factories. At Factory A, using the more rigorous technique, 44·3 per cent. of the Group I cases became infected before they healed. At Factory B, using the less rigorous routine, 75·0 per cent. of the Group I cases showed infection. This difference is statistically significant ($\chi^2=10{\cdot}61$, $P=0{\cdot}001$). When Groups I and II are considered together the incidence at A and B was 49·6 and 74·0 per cent. respectively.

The sepsis rates showed a trend in the same direction as the infection rates, but the differences in the incidence were not statistically significant: of Group I cases, 12·5 per cent. at A and 14·6 per cent. at B showed sepsis; the corresponding figures for Group I and II together were 9·5 and 15·1 per cent.

An investigation of wounds in an out-patient department (unpublished) has shown that initial contamination of the wound with *Staph. aureus*, and the carriage of the same organism on the skin, is associated with the subsequent development of staphylococcal infection. In Groups I and II the initial contamination rate with *Staph. aureus* was 12·6 per cent. at A and 29·0 per cent. at B. The skin carrier rates were 7·1 per cent. and 24·7 per cent. respectively. It is possible, therefore, that the higher infection rate at B was due to the greater prevalence of staphylococcal contamination and skin carriage, i.e. was determined entirely by factors outside the surgery. This point has been tested by comparing the infection rates at A and B in Group I and II patients whose wounds were not initially contaminated and whose skin adjacent to the wound was also free from *Staph. aureus* (Table 7). Of these cases, 67·4 per cent. became infected at B compared with 36·2 per cent. at A—again a highly significant difference ($\chi^2=10{\cdot}80$, $P=0{\cdot}001$). The difference in infection rates cannot therefore be attributed solely to the difference in contamination or skin carrier rates.

We have already seen that the sepsis rate among a group of wounds presented to the surgery on one day, such as we obtained in our preliminary survey, is an exaggerated index of the sepsis risk to clean wounds treated in the surgery, because of the prolonged attendance of the septic patients as compared with the clean. The sepsis rate for the Group I cases, i.e. patients who were observed for the whole course of healing, provides a more accurate index of this risk, but here again there may be an element of exaggeration. Patients may con-

TABLE 6

INCIDENCE OF SEPSIS AND INFECTION IN THE TWO FACTORIES

State of wound	Factory A				Factory B			
	Percentage in Groups—				Percentage in Groups—			
	I	I+ II	I+ II+ III	I+ II+ III+ IV	I	I+ II	I+ II+ III	I+ II+ III+ IV
Clean, clinically and bacteriologically	48·8	41·7	53·2	65·6	20·8	20·6	25·8	50·8
Infected with *Staph. aureus* and/or *Str. pyogenes*	38·7	39·4	31·6	23·2	70·9	71·2	66·9	44·4
Infected with pyogenic cocci and/or coliform organisms	44·3	49·6	41·1	30·2	75·0	74·0	69·3	46·0
Inflamed *	11·4	17·3	11·5	8·4	14·6	19·2	16·9	11·2
Septic *	12·5	9·5	5·7	4·2	14·6	15·1	10·5	6·9
No of wounds	88	127	209	285	48	73	124	187

Note.—It has been assumed that none of the patients in Groups II–IV became septic, inflamed or infected after default.

* i.e. clinical change with or without infection, see p. 146.

tinue to attend the surgery, and so be included in Group I, for various reasons: (1) The wound is septic and obviously needs treatment. (2) The wound is severe and obviously needs treatment; in these cases there is probably an increased risk of sepsis. (3) The patient may continue to attend for reasons other than those connected with the wound, e.g. hypochondria, attractive surgery conditions, etc. On the assumption that infection may be added during treatment, these wounds are exposed to a prolonged risk of infection. Thus Group I may include an undue proportion of septic wounds, leading to an overestimation of the risk of sepsis, for two reasons: patients may continue to attend because they are septic or markedly liable to sepsis, or they may become septic because they continue to attend the surgery.

TABLE 7

INCIDENCE OF INFECTION IN WOUNDS NOT INITIALLY CONTAMINATED WITH *STAPH. AUREUS*, WHERE THE PATIENT'S SKIN WAS ALSO FREE FROM THE ORGANISM

	No. of cases showing		Total	Percentage infected
	infection with *Staph. aureus*	no infection with *Staph. aureus*		
Factory A..	38	67	105	36·2
Factory B..	29	14	43	67·4
Total ..	67	81	148	45·2

$\chi^2 = 10{\cdot}80$; $P = 0{\cdot}001$.

On the other hand, if the sepsis rate is calculated from all the patients coming to the surgery, and therefore admitted to the series (Groups I, II, III and IV), irrespective of whether they were followed or not, the value will be too low since some patients may have developed sepsis after defaulting. It is probable, however, that this error is smaller than the error of overestimation because we may reasonably expect that a number of the patients who develop sepsis after default will return to the surgery. In Table 6 we have, therefore, calculated the sepsis and infection rates for Group I, Groups I+II, Groups I+II+III and Groups I+II+III+IV. The true sepsis rate, expressing the average risk of sepsis to a fresh wound attending the surgery, must lie somewhere between the limits of 12·5 and 4·2 per cent. at A, and between 14·6 and 6·9 per cent. at B. Similarly the true infection rate lay somewhere between 44·3 and 30·2 per cent. at A and between 75·0 and 46·0 per cent. at B.

Nature of the Infection. In the two factories, considering only the Group I cases, there were 18 wounds that showed sepsis. Ten were infected with *Staph. aureus* alone, two with *Staph. aureus* and *Str. pyogenes* together, and one with *Staph. aureus* and coliform organisms. From the remaining 5 cases none of these three organisms was isolated, most of them yielding micrococci only. We do not know whether the micrococci were acting as pathogens for these wounds; whether we failed to culture pyogenic cocci that were in fact present, because of inadequate swabbing; or whether, perhaps, the pathogens that would have been accessible to the swab had been killed by the tissue defences. (See Williams and Miles for further discussion of this point.)

The bacteriological findings in the 17 inflamed wounds were similar: *Staph. aureus* was isolated alone from 7; *Str. pyogenes* alone from one; coliform organisms alone from 2; and *Staph. aureus* and coliform organisms together from 4. Three wounds yielded non-pathogens only.

From 34 of the 101 clinically healthy wounds we isolated *Staph. aureus* alone; *Staph. aureus* and *Str. pyogenes* were isolated together from 2; *Staph. aureus* and coliform organisms from 7; and coliform organisms alone from 5. The remaining 53 wounds yielded none of these pathogens.

It is clear that *Staph. aureus* was the predominant pathogen for these wounds; it was isolated from 13 of the 18 septic wounds, from 11 of the 17 inflamed wounds, and from 43 of the 48 silently infected wounds. On the other hand, *Str. pyogenes* was isolated from only 2 septic, 1 inflamed, and 2 silently infected wounds. It was rare too as an initial contaminant, being present in only 7 of the 472 wounds swabbed, and was observed to persist in only one of these.

Coliform organisms were isolated from only one of the septic wounds, from 6 of the inflamed and from 12 of the silently infected wounds. In a number of cases a moist and sodden appearance of the wound was associated with infection by coliform organisms. We do not know if soddenness in a wound predisposes to infection by these organisms, or whether the sodden appearance is due to the infection; the same appearance was occasionally noticed in wounds infected with *Staph. aureus*. The wounds in this survey were too small and healed too quickly to allow us to determine whether coliform organisms delayed healing. Nevertheless delayed healing was observed in one wound at A persistently infected with an *Achromobacter* type of bacillus, and in another persistently infected with unidentified coliform organisms.

Conditions predisposing to Infection. In addition to swabbing the skin and wound at the time of first attendance we elicited a history of the accident, including the type of metal when the wound was inflicted by metal, and also noted the cleanliness of the patients' skin and clothing. We have been unable to demonstrate any association between the onset of infection and any of these factors; the number of wounds studied, however, was insufficient to allow us to exclude their influence.

Duration of Treatment. The healing time of the wounds in Group I, classified according to the clinical and bacteriological findings, are given in Table 8. There was a significant difference between the healing times of the clean and septic wounds at both factories; taking the results from both factories together, the clean wounds averaged 5·9 days to healing, the septic 18·2 days (*diff.* = 12·3 days, *S.E.d* = ±2·1 days; *diff.*/*S.E.d* = 6·0; $P = <0{\cdot}001$).

The mean healing time for the silently infected wounds was only slightly greater than that for the clean cases. Thus, taking the results from A and B together, 53 clean wounds took on an average 5·9 days to heal, compared with 6·3 days for the 48 silently infected wounds. At A there was a slight but not significant difference, the silently infected wounds taking 1·3 days longer to heal than the clean; at B there was no difference.

TABLE 8

HEALING TIMES OF THE WOUNDS (GROUP I)

State of wound	Factory A			Factory B			A and B together		
	No. of cases	H.T.	S.D.	No. of cases	H.T.	S.D.	No. of cases	H.T.	S.D.
Clean, clinically and bacteriologically	43	6·0	4·1	10	5·4	4·2	53	5·9	4·1
Silently infected	24	7·3	2·5	24	5·3	2·1	48	6·3	2·5
Inflamed	10	11·0	5·0	7	11·2	5·5	17	11·1	4·9
Septic	11	20·1	8·6	7	15·3	8·5	18	18·2	8·6

H.T.=healing time, days. S.D.=standard deviation, days.

Taking the two factories together, the difference is not more than a pointer (*diff.*=0·4 days, *S.E.d* $=\pm 0{\cdot}7$ days; *diff./S.E.d*=0·6) but it bears out our findings in a series of somewhat larger wounds treated at hospital, where 80 bacteriologically and clinically clean wounds took 15·6 days to heal, compared with 18·2 days for 58 silently infected wounds—a significant difference (*diff./S.E.d*=3·5, $P=<0{\cdot}001$).

DISCUSSION

Sepsis is generally admitted to be a numerically important complication of industrial wounds and is reported to be one of the chief causes of lost working time following accidents (Mock, 1915); to the patient it may mean prolonged and perhaps permanent disability. The wounds that we have surveyed were all small, none requiring hospital treatment; among them the incidence of sepsis was at least 5 per cent. This is not a very high proportion, but it has to be considered in relation to the very great number of minor wounds that occur in the industrial population. There are no accurate figures for the actual number of cuts that do occur, but in Factory A, employing some 6000 workers, there were 3470 attendances at the surgery with fresh cuts etc. in the six-month period July–December, 1943. It is probable that as many more were treated at the first-aid boxes in the factory, i.e. in a year each worker suffered between one and two cuts that needed some sort of treatment. Moreover the sepsis rate that we have recorded is for small wounds and we may expect a higher sepsis rate in larger wounds. For example, unpublished studies at Factory A in the latter half of 1943 showed that of 41 open wounds which at infliction were serious enough to incapacitate the patient for more than 3 days, 13 (32 per cent.) became septic before they healed.

Infection by the two pyogenic cocci is demonstrably responsible for the majority of cases of sepsis (Williams and Miles, 1945). Of the wounds sampled in our preliminary survey 48 per cent. were infected with pyogenic organisms, though only about 25 per cent. were clinically septic. The infection rate increased with the age of the wound and, furthermore, streptococcal infection, which was rare in fresh and recent wounds, was present in 54 per cent. of those more than 14 days old. Similar observations have been made on small wounds studied in hospital: the initial infection is usually staphylococcal; streptococci, on the other hand, commonly flourish only in wounds in which there is established staphylococcal infection (see also Williams and Miles). Our preliminary survey, therefore, suggested that infection was being introduced into the wounds during their healing. In hospital wards, opportunities for cross-infection occur with the greatest frequency during the dressing of the wounds (Miles *et al.*, 1940; Spooner, 1941; Williams *et al.*, 1945). During our preliminary survey in factory surgeries it was clear that numerous opportunities occurred during dressing for a similar transfer of organisms from one wound to another. Obvious instances were the use of fingers for performing wound dressings and the infrequency or total absence of hand-washing between cases, with accompanying contamination of wounds, dressing material, bowls, instruments, etc. Sterilizers, though usually available, were seldom used; bowls and instruments were often inadequately sterilized in spirit or some other disinfectant.

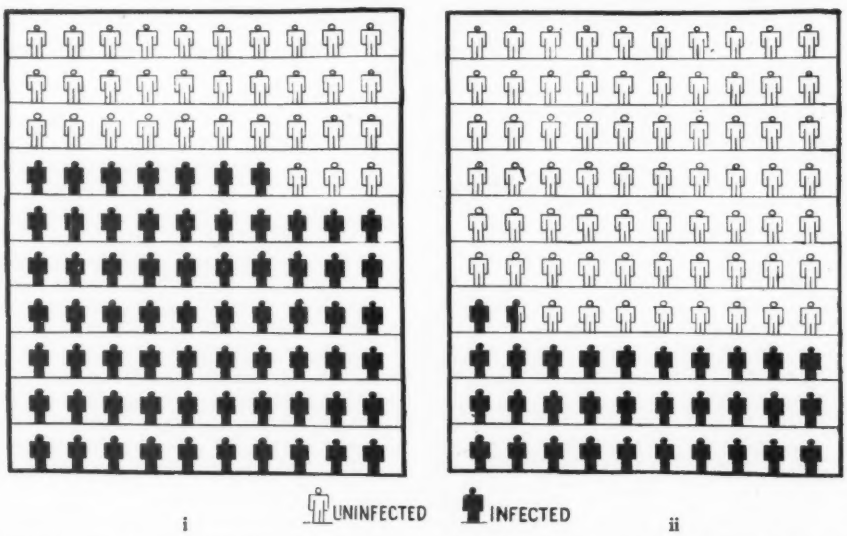
The association between the methods of wound dressing and the incidence of cross-infection, which has been demonstrated in hospital, appears to hold in the factory surgeries, for the infection rate among wounds treated with the more aseptic technique was significantly lower than that where the less rigorous technique was employed. There was, however, one external factor that might have accounted for the difference, namely, the greater number of wounds initially contaminated with *Staph. aureus* at the factory with the higher infection rate. But the infection rates in patients who had neither contaminated wounds nor *Staph. aureus* on the skin showed the same significant difference in the two factories. Thus elimination of the bias directly attributable to self-infection still leaves a difference between the infection rates at A and B. But the initial contamination of the wounds may also have had an indirect effect on the total infection rates in the two surgeries since wounds infected as a result of this contamination are reservoirs for cross-infection. It is arguable that the pre-

cautionary measures adopted at A and B were equally, though not completely, effective and the difference in total infection rates merely reflected the bigger risk of infection (concentration of reservoirs) at B. The data, however, give an indication that the risk from the reservoirs that arise as a result of cross-infection is greater than that from self-inflicted wounds. At A 11 of the 22 wounds either initially contaminated or on skin carriers, and 38 of the 105 uncontaminated wounds, became infected; at B, the corresponding figures were 23 of 30 and 29 of 43. If we assume that all the contaminated wounds that became infected did so as a result of self-infection, the cross-infected are 3·5 (38/11) times as numerous as the self-infected at A and 1·3 (29/23) times as numerous at B. But contaminated wounds are exposed to a risk of cross-infection and a number of them may in fact have been cross-infected. Combining the figures for both factories we see (Table 7) that the average infection rate for uncontaminated wounds is 67/148 (45 per cent.). Applying this rate to the 22 contaminated wounds at A and to the 30 at B, we should expect that 10 of them at A and 14 of them at B were cross-infected. This would leave one wound at A and 9 at B whose infection was attributable to the initial contamination. On this basis there were 48 times as many cross-infected as self-infected wounds at A and 6·2 times as many at B. The true ratio probably lies somewhere between these figures and the smaller ratios quoted above, but they are in any case sufficiently high to suggest that established self-infections constitute a numerically smaller risk than established cross-infections.

None of the other factors that we have studied—nature of the accident, nature of the material causing the wound, or cleanliness of the patient's skin or clothing—could be shown to be associated with an increased infection rate, nor were the proportions of the patients in these various classes notably different in the two factories. The wounds, too, were similar in size and site. It is possible that there were other differences in the methods of treating the wounds, apart from the aseptic technique, though none was conspicuous. More wounds were immobilized at A than at B, but at neither factory did such wounds form more than a small proportion of the wounds studied. Again, the difference may have been attributable to the different season at which the two factories were studied: A in the autumn and early winter, B in the late winter. We have no direct evidence about the influence of season on infection of these wounds but the surgery records at A for the past 3 years show no consistent seasonal change in the ratio of new attendances of patients with cuts that are septic when first seen to those with cuts that are clean when first seen. It seems unlikely, therefore, that a difference of the observed magnitude is attributable to seasonal variation.

In summary, taking into account our own and other workers' experience in studying cross-infection in hospital, we believe that the difference in aseptic methods made a substantial contribution to the observed difference in infection rates.

Manifest sepsis was not a common complication in either series of wounds; the majority of the infections were unaccompanied by clinical signs. These 'silent' infections are, however, important in three ways: (1) there is some evidence (Table 8 and unpublished work, see Miles, 1944) that the infection leads to delay in healing; (2) the wounds so infected constitute a large and unrecognized source from which pathogens may be transferred to



Summary Diagram.—A comparison of the percentage incidence of infection by pyogenic cocci in wounds seen one or more times after the initial attendance, in two factories employing different dressing techniques: (i) handling the wounds, and (ii) using a modified 'no-touch' technique (see page 148).

other, perhaps more susceptible, wounds; and (3) silent infections may on occasion become manifest later and the resulting sepsis lead to considerable disability. It is impossible to foretell the consequences of silent infection, either for the patient or for others, and though it is probable that in most patients the effect is small, the more serious consequences can only be guarded against by methods designed to reduce *all* added infection, whether silent or manifest.

In our opinion, the results clearly indicate the necessity for aseptic methods in handling even the small wounds that constitute the majority of those treated in the surgeries of engineering factories. A set of rules for such an aseptic routine has been outlined by one of us (Williams, 1944) and the performance of the routine is often facilitated by some reorganization of the lay-out of the surgery (Gissane, Miles, and Williams, 1944). We may note in this connection that the revision of aseptic measures that we have advocated has been proved to be practicable by a number of nurses in charge of large factory surgeries in Birmingham.

Summary

Of 531 small wounds and septic lesions examined in the surgeries of 19 different factories, 48 per cent. were infected with pyogenic cocci. In general, the older the wounds the higher was the infection rate.

A detailed comparison of 472 wounds treated in two factories engaged in similar work, but where different dressing routines were followed, showed that the incidence of infection was less in the surgery where the wounds were treated with a relatively rigorous no-touch dressing technique. In the surgery with the higher infection rate, where the wounds were handled more freely, the obvious deficiencies in the dressing routine were of the kind that would facilitate the spread of pyogenic microbes from one patient to another and it is highly probable that cross-infection of this kind was responsible for a substantial part of the difference in infection rates.

The extra burden of infection associated with the less rigorous technique is not *primarily* an indication for the adoption of a full aseptic routine since, in the small wounds studied, infection did not notably increase the average disability to the patient. Nevertheless the high incidence of infection indicates the existence of a risk which, in the long run, will manifest itself in occasional severe infection, particularly of large wounds; a risk which, in our opinion, can be substantially minimized by the adoption of a simple but rigorous routine of dressing.

Acknowledgments

Our thanks are due to the medical officers and nursing staffs of all the factories that we have visited, but particularly to those of the two factories where the detailed comparison was made, for the continuous co-operation that made the investigation possible.

We are also indebted to Dr. A. Bradford Hill for assistance in the analysis of the results, and to Dr. Donald Stewart and Dr. J. M. Davidson (lately H.M. Medical Inspector of Factories in Birmingham) for introducing us to many of the factories.

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HOT HUMID ENVIRONMENT:

ITS EFFECT ON THE PERFORMANCE OF A MOTOR CO-ORDINATION TEST

BY

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It is well known that prolonged stay in a hot humid environment, especially when the temperature of the body is raised, is accompanied by feelings of lassitude and irritability. In such conditions, as simulated in the laboratory, one is often aware also of a tendency to forgetfulness, to some 'slowing' of one's movements and there seems to be an enhanced liability to breakage of glassware and thermometers. Many observers of experiments in hot conditions have testified to such reactions.

During the course of some experiments on acclimatization to heat we had the opportunity of making a number of observations on the 'psychomotor' performance of resting and working subjects exposed to 'effective' temperatures above 90° F.* The results presented in this paper are regarded as preliminary only and of limited application to everyday activity in hot climates or occupations. However, as the findings seem sufficiently consistent we consider they support the belief that a measureable impairment of manual dexterity or co-ordination occurs at high environmental temperatures.

Experiments

The test of motor co-ordination used throughout the experiments was one devised by the Cambridge Psychological Laboratory. The apparatus consists of a gramophone disc rotated at constant speed by an electric motor. This gramophone top is mounted at an inclination of 13° to the horizontal and carries a bakelite plate provided with an inner and outer series of perforations. The task set for the subject is as follows: using a pair of forceps, and in as short a time as he is able, the subject is required to pick up from the inner circle of holes each of 84 small steel ball-bearings ($\frac{3}{8}$ inch) and deposit these in the outer series of holes while the gramophone disc is rotating. Any balls which are not accurately placed in the holes or which slip from the forceps, run down the sloping disc into a tray from which they must be picked up until all the balls have been successfully deposited. The subject then returns the balls from the outer circle of holes to the inner, retrieving any dropped balls from the tray as before. This transfer of balls from the inner to the outer ring and back to the inner constitutes a complete 'run.' Two minutes after the completion of the first run the second run is performed, and after a rest of 15 seconds the third run is performed. The time taken to complete each run is noted by means of a stop-watch and the total test time for the three runs is thus obtained. The number of balls retrieved from the tray for each run is also noted and hence the total number of balls actually handled during each run is known. Since the time for each run is recorded, the average time taken to handle each ball can be calculated.

A preliminary series of experiments was carried out on 4 subjects, MacM, M, T, and Rh, aged between 20 and 30 years. They had three weeks practice at ordinary room temperature and then carried out the co-ordination test after two hours exposure nude in an environment of dry bulb 95° F. and wet bulb 90° F., air movement 30 feet per minute, giving a temperature of 91° F. on the effective temperature scale (Houghten, Teague and Miller, 1926). These subjects were not acclimatized to a hot environment. On two of the subjects the test in the hot room was repeated on a second occasion. The rectal temperatures during these tests were scarcely raised. Control tests at ordinary room temperature (dry bulb 65° to 68° F.) were done on the same day or within a few days of the test in the hot room.

In the main series of experiments the 6 subjects, aged 25 to 35, were well acclimatized to working in hot humid environments. The co-ordination test was carried out at dry bulb 95° F. and wet bulb 90° F., air movement 30 feet per minute, 'effective' temperature 91° F. The subjects were also well practised in the co-ordination test; subjects R, P, B, and H, had performed 27, 23, 24, and 20 practice runs respectively on successive days, excluding Saturdays and Sundays, before the actual tests in the hot room. The two other subjects, MacK and W carried out only 11 preliminary runs. As the effect of practice is very marked in ordinary room conditions the tests were continued in such conditions after the experiment in the hot room. This enables one to compare the performance in the hot room with the average performance in ordinary room temperature before and after the test in the hot room. The tests at high environmental temperatures were arranged as follows: the subject carried out two bouts of step climbing on a 12-inch block 24 times per minute for 10 minutes with a pause of 5 minutes in between the 10 minute bouts. The exercise raised the rectal temperature in most subjects to over 101° F. and this temperature was maintained steadily or dropped only slowly during the next hour in the hot room. An hour after the work when the pulse rate had become steady the

* The 'effective temperature' of an atmosphere (Houghten, F. C., Teague, W. W., and Miller, W. E., 1926) is the temperature of a still, saturated atmosphere which will produce the same feeling of warmth as the atmosphere in question.

co-ordination test was performed in the manner already described. The men were allowed to dry their faces and hands of sweat before each run of the test. The clothing worn in all experiments consisted of Bush shirt (open at the neck) drill trousers, army boots and socks. Control experiments were carried out in the same chamber at temperatures similar to that of ordinary room conditions. The subjects performed the psychomotor test after carrying out the same amount of work as in the heat.

A further experiment involving a prolonged stay in the hot room was carried out on one subject, L, aged 32. He was unacclimatized to the heat but had carried out a series of practice tests in ordinary room conditions for ten days. During the tests in the hot room he lived nude in the hot humid environment for 13 days. During the mornings he performed the co-ordination test at an 'effective' temperature of 82° F. He then carried out certain routine observations in connection with tests on other subjects at a temperature of dry bulb 100° F. and wet bulb 94° F., 'effective' temperature 95° F. During the afternoon he carried out two hours step-climbing and forthwith performed the co-ordination test at an 'effective' temperature of about 86° F. This 'effective' temperature varied from day to day during the 12 days, ranging between 82° F. and 90° F. Thus, during the morning co-ordination test his rectal temperature was normal (average 98·7° F.) and during the afternoon tests it was markedly raised (average 103·2° F.) as a result of the day's exercise. He slept in an environment of 'effective' temperature 82° F. After 13 days of this routine the subject left the hot room and then carried on with a series of control tests in ordinary room temperature for the next six days.

Results

Preliminary Tests on Resting Subjects, Single Exposure

From the figures for the total test time, given in Table 1, it can be seen that in every case there was an impairment of performance during exposure to heat. The increase in the time taken to perform the test averages 8 per cent. for the 4 subjects. Thus, exposure to a hot humid environment without any rise in rectal temperature may impair co-ordination of fine movements. In these preliminary tests the effect of the environment on the number of balls dropped and the speed of movement was not measured.

TABLE 1

PRELIMINARY TEST ON RESTING SUBJECTS. SINGLE EXPOSURE

Subject	Mean test time in cool, secs.	No. of tests	Mean test time in heat, secs.	No. of tests
MacM	960	2	987	1
M	889	4	963	2
T	1110	3	1245	2
Rh	834	3	897	1
Mean	948	—	1023	—

Mean difference in test time=75 secs.
Deterioration=8 per cent.

Acclimatized Subjects, after Work, Single Exposure

The essential information is set out in Table 2. This records the total test time, the number of balls dropped and the speed of movement per ball, of the 6 subjects, (*a*) in the hot room after previous muscular work in comparison with relevant performances in ordinary room temperature without performance of work, and (*b*) at ordinary room temperature after previous work, in comparison with the relevant series of performances without previous work.

For purposes of comparison, the series of tests with work in the hot room and the series with work in ordinary room temperature were both compared with the learning curve (tests without work in the cold) and not with one another. This was necessary because the two sets of co-ordination tests involving muscular work were carried out in the case of most of the subjects over lengths of time not falling in quite the same period of the individual learning curve.

For estimating the effect of exposure to heat, the total variance is obtained by pooling the variance of the individual observations about the mean score for the different subjects, using the ordinary room temperature only. This was necessary because only one observation was made on each subject in the hot room. For the estimation of the effect of previous muscular work on co-ordination, both series of tests in ordinary room temperature are used to obtain the pooled variance.*

Total Test Time Scores

1. There is no significant difference between the means of performance in ordinary room temperatures, whether or not exercise was carried out prior to the psychomotor tests.

2. The total test time in the hot room was longer than that in ordinary room temperature. The probability that this difference is due to chance is very small (P=0·01–0·001). The difference in the mean test time in the heat from that in ordinary room temperature was 14 per cent.

Number of Balls Dropped

Here again the effect of exposure to heat is marked (P=0·001). The accuracy of the subjects in handling the balls was impaired in the hot room. The difference between the two series of experiments at ordinary room temperature was not significant.

Time per Movement per Ball

Here also the effect of exposure to heat was significant (P=0·02–0·01). The movements of the subjects were slower in the hot room than in ordinary room temperature by 0·09 second per movement,

* 'Student's' test was used to estimate the significance of the difference between the 'grand' means shown in Table 2. This test consists essentially in a comparison of the difference between two means with its standard deviation. To assess the probability that the difference between the means is due to chance, the value of P is found from a table of P and *t* in which the number of degrees of freedom available for estimating the standard deviation is taken into account. Thus if P is found from the table to be 0·01, the probability that the observed difference between the means would arise by chance is 1 in 100.

TABLE 2

ACCLIMATIZED SUBJECTS AFTER WORK. SINGLE EXPOSURE

(Note x = individual test performance)

Subject	In hot room after work	Rectal temperature, °F.	In ordinary room temperature, no work	Degrees of freedom, n	$\Sigma(x-\bar{x})^2$	t	In ordinary room temperature, no work	Degrees of freedom, n	$\Sigma(x-\bar{x})^2$	In ordinary room temperature, no work	Degrees of freedom, n	$\Sigma(x-\bar{x})^2$	t
	TOTAL TEST TIME												
	Test time, seconds		Mean test time, seconds $\bar{x}$				Mean test time, seconds $\bar{x}$			Mean test time, seconds $\bar{x}$			
R	1065	101·1	873	5	66,534	—	898	3	10,174	874	5	66,534	—
P	746	100·0	693	5	18,257	—	684	3	1,530	693	5	18,257	—
B	928	102·2	893	5	25,618	—	1017	4	7,149	1040	5	34,087	—
H	851	103·0	667	3	1,909	—	755	3	15,640	717	7	5,980	—
MacK	1121	100·4	989	1	392	—	1218	0	—	1224	3	125,582	—
W	733	100·0	655	1	200	—	771	0	—	765	3	17,502	—
Total	5444	606·7	4770	20	112,910	3·30	5343	13	—	5313	41	302,435	0·20
Grand mean	907	101·1	795	—	5,645	P=0·01–0·001	891	—	—	886	—	7,376	P=0·8
	NUMBER OF BALLS DROPPED												
	Number of balls dropped		Mean number of balls dropped $\bar{x}$				Mean number of balls dropped $\bar{x}$			Mean number of balls dropped $\bar{x}$			
R	218	101·1	171	5	59,748	—	160	3	3,933	171	5	59,748	—
P	80	100·0	55	5	4,369	—	56	3	502	55	5	4,369	—
B	159	102·2	119	5	1,891	—	164	4	5,977	166	5	5,154	—
H	132	103·0	53	3	8,596	—	93	3	3,749	68	7	2,702	—
MacK	138	100·4	83	1	722	—	123	0	—	110	3	3,605	—
W	112	100·0	92	1	313	—	133	0	—	126	3	727	—
Total	839	606·7	573	20	75,639	5·11	729	13	—	696	41	90,466	0·39
Grand mean	140	101·1	95	—	3,782	P=0·001	121	—	—	116	—	2,206	P=0·7
	TIME PER MOVEMENT PER BALL												
	Time/ movement, seconds		Mean time/ movement, seconds $\bar{x}$				Mean time/ movement seconds $\bar{x}$			Mean time/ movement, seconds $\bar{x}$			
R	1·47	101·1	1·31	5	0·0543	—	1·35	3	0·0305	1·31	5	0·0543	—
P	1·27	100·0	1·23	5	0·0119	—	1·22	3	0·0006	1·23	5	0·0119	—
B	1·39	102·2	1·39	5	0·0079	—	1·53	4	0·0178	1·55	5	0·0400	—
H	1·39	103·0	1·19	3	0·0067	—	1·26	3	0·0207	1·25	7	0·0148	—
MacK	1·73	100·4	1·68	1	0·0018	—	1·93	0	—	1·99	3	0·2275	—
W	1·19	100·0	1·10	1	0·0002	—	1·26	0	—	1·21	3	0·0253	—
Total	8·44	606·7	7·90	20	0·0828	3·09	8·49	13	—	8·54	41	0·4434	0·0
Grand mean	1·41	101·1	1·32	—	0·0041	P=0·02–0·01	1·42	—	—	1·42	—	0·0108	—

or by an average of 6 per cent.; since more balls were dropped in the hot room, part of this extra time per movement may be due to the fact that the movements to retrieve balls when dropped took longer than the other movements from one set of holes to the other. Exposure to the heat caused the subjects to revert in their performances to those given early on in their practice series, i.e. when first learning the test. In those practice tests the subjects also dropped more balls and moved more slowly than on subsequent days when improvement became noticeable.

Prolonged Exposure (Subject L)

Table 3 gives L's average performance (total test time, number of balls dropped and speed of movement) for the last four days of the practice period before going into the hot room, for the first four and the last six days in the hot room, and for six days after leaving the hot room.

TABLE 3

SUBJECT L. CONTINUED EXPOSURE TO HOT ENVIRONMENT

		Cool control before entering hot room last 4 days	First 4 days in hot room	Last 6 days in hot room	Six days cool control after being in hot room
Mean total test time (secs).	a.m.	652	738	680	625
	p.m.	687	743	650	639
Mean No. of balls dropped.	a.m.	83	69	65	57
	p.m.	99	99	61	60
Mean time per movement (secs.).	a.m.	1·11	1·28	1·19	1·11
	p.m.	1·14	1·23	1·13	1·12

This subject exhibited a learning curve in ordinary room temperature similar to that of the other subjects; his speed of movement became quicker on succeeding days, but he did not show any improvement as regards the number of balls dropped; his total performance time improved markedly but had become steady at the end of the practice period. On entering the hot room his performance was at first very much worse; while the number of balls dropped did not alter much, the time taken per movement was markedly increased. Consequently the total test time was longer (11 per cent.). His performance in the hot room thus reverted to that found at the beginning of the practice series in ordinary room temperature.

With further stay in the hot room the subject's performance improved rapidly until during the last six days it was practically as good as it was before he entered the hot room. This improvement was chiefly in the speed of movement but he also dropped less balls.

During the first few days in the hot room the time for completing the test was about the same in the mornings as in the afternoons although his rectal temperature was raised in the afternoons. In the final period in the hot room the total test time was actually less in the afternoon than it was in the morning, chiefly because the speed of movement was greater.

In this subject it can be seen that the exposure to the hot environment and not specifically the rise in rectal temperature had affected his performance. During the six control days after leaving the hot room L's performance was somewhat better than it was before the experiments in the hot room and consequently better than his performance during the last few days in the hot room.

Comments

From all these experiments it appears that motor co-ordination is impaired in a hot humid environment. The experiments suggest that any raising of rectal temperature consequent on work in hot humid environments may not materially increase the impairment. The experiments on the subject L suggest also that 'acclimatization' of motor co-ordination to a hot humid environment analogous to 'acclimatization' to work takes place. However, the process of this 'acclimatization' must be distinct from physiological acclimatization to work in the hot room since the subjects P, R, B, H, MacK, and W, who were already acclimatized to work in the hot room nevertheless gave an impaired co-ordination performance in the hot room.

In a study from the Research Laboratory, American Society of Heating and Ventilating Engineers, made on behalf of the U.S. Navy, it was found that deterioration as measured by reduced output and accuracy in various psychomotor tests took place at 'effective' temperatures of 87° F. and 94° F. It is interesting to note that the tests used were all different from the one described in this report.

Summary

Three groups of experimental subjects—resting nude subjects given a short exposure to an 'effective' temperature of 91° F., clothed subjects after work in an environment of 'effective' temperature 88° F., and a nude subject during long exposure to an environment of 'effective' temperature 82° F.–96° F. both resting and after work, all showed deterioration in the performance of a psychomotor co-ordination test.

The deterioration in performance was due to slowness of movement and in most of the subjects to inaccuracy in handling the balls.

Acknowledgements

We are indebted to Dr. E. Arnold Carmichael for his encouragement in this investigation and to Lady Frankau for bringing the co-ordination test to our notice; to Dr. Irwin for statistical advice and to Dr. Ladell for his co-operation in carrying out certain of the tests. The instrument was constructed by Major H. C. Holden, R. A. We also express our gratitude to the R.A.M.C. personnel for acting as subjects in the somewhat arduous tests.

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EDUCATION IN INDUSTRIAL HEALTH

Report of the Education Committee of the Association of Industrial Medical Officers *

Introduction

In 1941 the Association of Industrial Medical Officers prepared a memorandum, 'Training of Industrial Medical Officers', which was published in that year by the British Medical Association as an appendix to its report on industrial health. This memorandum outlined schemes both for war-time and for peace-time. While the principles laid down in the peace-time scheme need little amendment, the Committee proposes to review the problem of education in industrial health more widely, in the light of recent reports on medical education and on the development of industrial medicine. The first report of the Social and Preventive Medicine Committee of the Royal College of Physicians of London (1943) drew attention to the need for education in industrial medicine. The second report of the same Committee (1945), entitled 'Industrial Medicine', went further. It discussed in some detail the need for education of medical officers for industry: for part-time service there would appear to be a need for a short course, lasting perhaps six weeks; for the medical man or woman who wishes to take up industrial health as a career, and whether a special diploma in industrial health is instituted or not, there should be a well-designed course of academic and practical training of one year's duration.

The white paper published by the Ministry of Health on a national health service (1944) makes little mention of occupational medicine, and no mention at all of the need for education in its principles. The Report of an Inter-Departmental Committee on Medical Schools (1944)—the Goodenough report on medical education—makes some mention in a chapter on social medicine of the need for undergraduate training in industrial medicine: during the clinical period the student's training in social medicine should include personal investigations of industrial conditions by visiting the patient's place of employment. In discussing development in post-graduate education the Goodenough report states (p. 219): 'Special provision should be made for instruction in industrial medicine and it is a matter for consideration whether this should form an optional part of the public health course or be organized separately.' While the report refers to the need for organization of post-graduate courses of training for medical practitioners demobilized from the services, it does not specifically mention industrial medicine as a future opening for some of these practitioners, nor the need for education in it as part of these courses.*

From the brief survey which follows it will be seen that there are considerable opportunities for doctors to become engaged in a whole-time or part-time capacity in one or other of the branches of industrial health service. It is a matter for disappointment that, so far, no plan of any kind for the future development of this service has been evolved by a responsible Government department. The white paper on 'A National Health Service' dismisses industry in a few words. But the Royal College of Physicians of London, in its recent report already mentioned, has done much to emphasize the importance of industrial health and to plan for the future; so it is hoped that its recommendations will be fully considered. If so there should be important developments in this new branch of medicine in the not too distant future. No national health service can be adequate that does not include, as an integral and properly co-ordinated part of the whole, an industrial health service. For this reason adequate facilities for education and training of those doctors, nurses, and others who take part in it, must be provided at the earliest opportunity.

Scope of Industrial Medical Practice

There is no national industrial medical service in this country. The great majority of large employers and many hundreds of smaller firms have their private medical service. But there is, at the present time, no co-ordination between these services and Government departments concerned with health, or with the hospital and general practitioner service of the country. It should be remembered that 'industry' consists, in reality, of all employed persons, not only those, for example, in factories and mines. The number of such 'employed persons' under peace-time conditions is 13 million men and over 4 million women.†

In so far as it has been able to obtain facts ‡ the

* Membership of the Committee was as follows: Drs. W. E. Chiesman (Chairman), J. C. Bridge, Donald Hunter, R. E. Lane, T. A. Lloyd Davies, T. Gwynne Maitland, D. C. Norris, C. L. Potts, R. S. F. Schilling, Donald Stewart, and K. M. A. Perry (Secretary).

* It is of interest to note that the Nuffield Foundation has announced (April, 1945) that it is prepared to award a limited number of fellowships—normally worth £500–£800 a year—to men and women who wish to qualify for teaching and research posts in industrial health. Medical officers in the forces can apply for these fellowships which would become tenable on demobilization.

† Social Insurance, Part 1 (1944). H.M.S.O. Lond., p. 48.

‡ In preparing this report the Committee has had assistance from certain individuals and Government departments,

Committee wishes briefly to outline the scope of present-day industrial medical practice in the various branches of British industry.

(a) **Factories**

In 1938 the estimated number of factory workers was between 6 and 7 million—a number much increased in war-time. The following is a list of the different branches of industrial medicine engaged one way or another with the health supervision of these men and women.*

(i) **Factory Medical Inspectorate.** The Factory Department was formerly in the Home Office but in 1940 was transferred to the Ministry of Labour and National Service. It is the oldest Government department dealing with industrial health and comprises general factory inspectors, electrical inspectors, chemical inspectors, engineering inspectors and medical inspectors. It administers those statutory regulations which deal with the many aspects of health and safety in factories, welfare, first aid, notification and investigation of accidents and industrial disease, hours of work, employment of women and young persons, and canteens. At the present time there are ten whole-time medical inspectors of factories who investigate conditions of work with particular reference to occupational diseases, and advise the lay inspectorate on other medical issues which may arise. They are stationed in London, Birmingham, Bristol, Leeds, Liverpool, Manchester, Sheffield and Glasgow.

(ii) **Examining Surgeons.** Under supervision of the Factory Department some 1750 general practitioners throughout the country give service as examining surgeons under the Factories Act. Their duties consist in medical examination of all young persons under 16 years of age entering factories for employment and those between 16 and 18 employed on certain processes; periodic examination of persons engaged in certain dangerous processes; investigation and reports on cases of industrial disease; and examination and issue of certificates to those persons claiming compensation for scheduled diseases under the Workmen's Compensation Act.

(iii) **Factory Medical Officers.** Medical officers in factories, whether employed whole or part-time, constitute the main bulk of industrial medical officers. They act as an important link between industry and the general practitioner and hospital services. At the present time there are some 250 whole-time and over 700 part-time doctors working in factories.† The work of these doctors ‡ varies with the type of industry in which they are employed. Broadly speaking their duties consist of (a) emergency treatment of injuries and sickness at the place of work; (b) end stages in rehabilitation; and (c) the many preventive measures which can be taken within the factory itself against accident, ill-health, or occupational disease. This work offers wide opportunities for research in health and social problems.

(iv) **Factory Nurses.** At the present time it is estimated that approximately 9000 nurses are employed in factories, 5000 of them being state registered (S.R.N.). These nurses work in the following categories:

(*a*) assistant nurses working on their own, or under supervision of a nurse (S.R.N.) or doctor;
(*b*) nurses (S.R.N.) working under a senior nurse who is responsible to a doctor;
(*c*) nurses (S.R.N.) working in groups but each personally responsible to the doctor;
(*d*) nurses (S.R.N.) working in factories where there is no medical supervision; and
(*e*) senior nurses (S.R.N.) responsible to a doctor for groups of nurses in categories (*a*) and (*b*).

(b) **Mines**

A Mines Medical Service is run by the Mines Department of the Ministry of Fuel and Power; it consists of ten whole-time doctors, two at headquarters in London, and eight regional mines medical officers. The number of miners in this country is approximately 750,000. Much of the work of the regional medical staff is concerned with applications for release from the industry on medical grounds, but it has always been realized that this activity, essential as it is at present, is not their ultimate function.* Medical officers are therefore encouraged to devote as much time as possible to prevention of disease and accidents below ground, to consideration of working environment, and to link up with hospitals, rehabilitation centres, and other institutions to which miners go for treatment. A small number of collieries have, in addition to facilities provided by the state service, their own medical officers, most of them in a part-time capacity. There are 6 whole-time medical officers in this industry appointed by private employers. As far as the Committee can determine the number of women nurses employed by collieries is negligible.

(c) **Quarries**

Quarries employ some 75,000 persons and for health and safety purposes come within the scope of the Mines Department; but if a manufacturing process such as the making of tar macadam is carried out in a quarry this falls within the scope of the Factory Department.

(d) **Docks**

Docks employ over 106,000 workers and separate medical services for them have been established in

but it must be admitted that because of the many different departments concerned and the lack of a co-ordinating medium of any kind, there has been much difficulty in obtaining data. The Committee therefore presents these figures as being the most accurate available.

* The Silicosis and Asbestosis Board (*v.i.*) is also concerned with certain aspects of health supervision of factory workers.

† See R.C.P. Report 'Industrial Medicine' (1945), p. 7.

‡ *Medical Supervision in Factories* (1944). H.M.S.O. Lond.; see also Report of Committee on Industrial Health in Factories (1941). B.M.A. Lond., p. 9.

* *Brit. J. industr. Med.*, 1944, **1**, 153; *ibid.*, 198.

Liverpool, Manchester and Glasgow, and one is now being devised for London. These services necessitate the appointment of adequate medical and nursing staff.

(e) Shipbuilding

Where organized medical services exist in this industry the work of the medical officers is comparable to that of the factory medical officer, shipyards coming under the Factories Act.

(f) Shipping

The shipping industry employs some 160,000 men —sailors in the Merchant Navy. There are approximately 300 whole-time ship surgeons whose work, if properly carried out, must include them within the ranks of industrial medical officers.* In addition approximately 1000 doctors at any one time, under conditions of peace, are employed as temporary ship surgeons. British ship surgeons, unlike those in certain other countries, are not required to attend courses in maritime hygiene, so here is an immediate field for health training for this industry. It has been suggested that special courses of instruction could well be carried out at the Universities of London, Liverpool, and Glasgow, as the responsibility of a Department of Industrial Health.

(g) Railways. Road Transport

The number of railway employees at April, 1943, and including the London Passenger Transport Board was 668,145 men and 135,000 women.† Doctors employed by railways and road transport are at present mainly concerned with the fitness of applicants for employment and with questions of compensation. This to some extent enables them to see that their workers get appropriate treatment and rehabilitation, but it very considerably limits the scope of such doctors as compared, for example, with that of the factory doctor. Only 16 whole-time doctors are employed by the railways, and 7 whole-time doctors by road transport undertakings.

(h) Other Industries

The General Post Office employs over half a million workpeople. There is a chief medical officer and 10 medical officers at the G.P.O. Headquarters in London. Their work consists largely of the supervision of sick absence. The junior members of the staff are also concerned with the personal home care of the staff in the London area, i.e. they carry out general practice.‡

A few large commercial undertakings and retail stores employ whole- or part-time medical officers.

As far as the Committee can determine there is no medical supervision of agricultural workers, or any organized medical supervision of workers in the building industry. In 1944 there were 778,000 men and 227,000 women engaged as farm workers in the United Kingdom;* and just before the war the number of persons engaged in the building industry on constructional work was a quarter of a million: this figure is likely to increase very considerably in post-war years.

(k) The Silicosis and Asbestosis Medical Board

This Board consists of a senior medical officer and 10 other whole-time doctors—all with special knowledge of chest diseases—and comprises panels stationed in Sheffield, Swansea, Cardiff, Stoke-on-Trent and Manchester. The panels examine and issue certificates of compensation to workers who develop silicosis and asbestosis. Workers on certain processes liable to produce these conditions are periodically examined by members of the Board.

(l) Research Workers in Industrial Health

Since the last war, the Medical Research Council's Industrial Health Research Board has employed a staff of research workers, many of them non-medical.† These workers have largely been separated from hospital, but while this does not greatly matter for statistical, social, or psychological work, it can be a disadvantage where disease is being investigated, as departments such as bacteriology, morbid anatomy, bio-chemistry and radiology have a part to play in these researches. In June, 1943, the Medical Research Council created the Department of Research in Industrial Medicine at the London Hospital. In May, 1944, the Council established at Cambridge a unit for research in applied psychology, and in June, 1945, a unit at Cardiff for research on pneumokoniosis.

The Ministry of Supply experimental station at Porton is concerned primarily with chemical warfare. Many of the problems in this sphere are similar to those of industrial toxicology, and it is well equipped to carry out specific investigations: with a chemical department, a physical department, and a physiological department equipped with animal houses. After the war it seems probable that the ordinary work carried out here will be greatly reduced, and the possibility of industrial problems being studied there is one that needs serious consideration.

That there is urgent need for good research workers to give their attention to problems of industrial health cannot therefore be denied. Some of the problems for future investigation have been recently outlined by the Secretary of the Industrial Health Research Board,‡ and it will be for the heads of the new University Departments of Industrial Health both to help find the right men and women and to train them for this work. It must be emphasized, however, that the practising industrial medical officer has much scope for research, and provided his work is properly co-ordinated his

* *Brit. J. industr. Med.*, 1945, **2**, 109.
† Whitaker's Almanack, 1945, p. 646.
‡ The General Post Office is allowed by Parliament to contract out of National Health Insurance, and 2600 Post Office medical officers are appointed for this work throughout the country. The work is that of a panel doctor, and they are paid on a *per capita* basis.

* Whitaker's Almanack, 1945, p. 634.
† The present staff numbers 7 doctors, and 25 physiologists, chemists, physicists, psychologists, statisticians, and technical and laboratory assistants.
‡ Schilling, R. S. F. (1944). *Brit. J. industr. Med.*, **1**, 145.

contribution in this field can become of much importance.

(m) **Ministry of National Insurance**

The proposals of the Government concerning workmen's compensation* must lead to the appointment of doctors with knowledge of occupation to deal with 'claims in respect of disablement'; to become 'appointed medical officers' or medical referees; to sit on 'local appeal tribunals' if required; and to act as members of 'medical boards'. In connexion with this last category the Government suggest that 'the Medical Boards of the Ministry of Pensions might be utilized for this purpose.' If this new legislation is to be effective it is vitally necessary that these members of the medical profession should have adequate training in industrial health, for theirs will be a great responsibility.

Present Teaching Facilities

An inquiry into the extent to which the teaching of industrial health is carried on in the medical schools at the present time revealed that instruction was extremely scanty in London and not much better in the provinces. The table on page 162 gives a summary of the information which was obtained.

Hospitals and Industrial Health. Hospital physicians and surgeons have three distinct functions: the curing of illness, research, and teaching. Training of students, doctors, nurses and almoners (medico-social service workers) must therefore be based to some extent on the teaching hospitals, so their relationship to industry is important.

In regard to the curing of illness the patient's occupational background is the concern of hospitals in the following ways.

(*a*) Patients disabled by trauma must be given adequate treatment and rehabilitation so that they may return to their old employment; if this is not possible, treatment should not be regarded as finished until training for new employment is completed and found satisfactory. In this connexion hospitals will, in the future, link up closely with the Ministry of Labour, and, through hospital social service or almoners' departments, with individual employers.† Similar guiding principles must also be accepted for patients disabled by ill-health and disease. Patients may frequently have to be advised as to suitable employment; this implies a knowledge of work and work environment on the part of hospital consultants which, at present, is almost non-existent. It is of fundamental importance, therefore, that hospital staffs should be provided with facilities for obtaining information in this direction.

(*b*) Diagnosis and treatment of occupational diseases arising in industry. While the treatment of pneumonia, rheumatism, gastric conditions, or of tuberculosis is of great importance to the individual, the community, and therefore to industry, it must be remembered that there is an ever-present risk of disease being caused directly by occupation. Diseases such as pneumokoniosis, for example, may produce wide problems. Thus there is great opportunity for hospitals to become service departments for industry, particularly in urban areas.

(*c*) Psychiatric problems commonly arise in industry and specialist advice is often essential. There is ample evidence of the need for collaboration between hospital psychiatrists and industry.*

* Social Insurance, Part II: 'Workmen's Compensation' (1944). Cmd.6551. H.M.S.O. Lond., p. 20 *et seq.*; National Insurance (Industrial Injuries) Bill (1945). H.M.S.O. Lond.; Explanatory Memorandum (on the Bill) by the Minister of National Insurance (1945). Cmd.6651. H.M.S.O. Lond.

† Under the Disabled Persons (Employment) Act, 1944, this link has already begun to be established.

Recommendations

University Departments of Industrial Health

The Nuffield Foundation has recently endowed a chair of industrial health in the University of Manchester, and Dr. R. E. Lane has been appointed to take up duties as Professor in September, 1945. Readerships in industrial health have also been endowed by the Foundation in the Universities of Durham and Glasgow, but no appointments have so far been made (July 1945). The University of Durham has now decided (May 1945) to implement the Nuffield gift so as to create a chair of industrial health. If the Universities of London, Birmingham, and Liverpool were to follow suit the Committee is of the opinion that the needs of the country in this direction would be adequately covered.

Medical Undergraduate Training.

Education of medical undergraduates must be directed to making them conscious that a patient has an occupation, that this may have some bearing on the cause of his illness, that the economic results of illness have important repercussions, and that his treatment is not complete until he is again able to earn his living. The undergraduate is not required to become a specialist in occupational health, and only a limited amount of time can be devoted to its study. Much of the instruction can be given during the student's clerkship in the medical and surgical wards. Teachers of medicine and surgery should themselves understand something of the principles of industrial health. The student should also receive a course of at least six lectures on occupational medicine and spend at least three days within the factory when the normal work of the industrial medical officer can be explained to him. He should receive instruction in the departments of accident surgery, social medicine and psychiatry, where they exist, on the relation between these subjects and industry.

Medical Post-graduate Training.

It is not easy to lay down hard and fast rules for the training of industrial medical officers. It is important that recruits to this sphere should have

* *Brit. J. industr. Med.*, 1945, **2**, 41.

ANNUAL TEACHING IN INDUSTRIAL HEALTH

Hospital or University	Undergraduate	Post-graduate	Nurses *	Almoners
London Hospitals				
Charing Cross ..	Fracture clinic.			
Guy's	Lectures in public health course.		Lectures.	
King's College ..	Lectures and visit to factory.			
London	9 lectures.			
Royal Free	Nil.			
Middlesex	Nil.			
St. Bartholomew's	As part of course of 20 lectures in state medicine.			
St. George's ..	2 lectures.			
St. Mary's	Nil.			
St. Thomas's ..	Lectures from time to time by industrial medical officers.			
University College	Lectures in course on social medicine.			Attend lectures in social medicine course.
Westminster ..	6 lectures; visits to factories.			
West London ..	Nil.			
London School of Hygiene.	Nil.	20 lectures in D.P.H. course.†		
Birmingham	Nil.	Course of 6 lectures 3 times a year.	(*a*) 1 year's course. (*b*) 3 one-day courses.	
Bristol	2 lectures.	2 week-end courses.	1 week-end. 1 3 months' course.	
Cambridge	Nil.			
Durham	Nil.			
Leeds	Nil.	1-day. Occasional week-end course.	1-day courses with College of Nursing.	
Liverpool	Nil.			
Manchester	6 lectures; dresserships in factories.	(*a*) Course of 6 lectures 3 times a year. (*b*) 6 lectures in occupational health (D.P.H. course).†	Three 1-day courses.	1 week-end.
Oxford	Nil.			
Sheffield	Lectures.	2 week-end courses; visits to factories.		
Wales	2 lectures; 1 visit to factory.	D.P.H. course.†		
Aberdeen	8 lectures in public health course.	7 lectures in D.P.H. course.†		
Edinburgh	2 lectures; visits to factories.	6 lectures in D.P.H. course.†		Attend lectures in D.P.H. course.†
Glasgow	3 lectures.	9 lectures.	3 months' course with College of Nursing.	
St. Andrew's	3 lectures.	10 lectures in D.P.H. course.†		

* For account of courses held by the Royal College of Nursing, see *Brit. J. industr. Med.*, 1944, **1**, 89. The University of London, for its Diploma in Nursing, allows 'Industrial Nursing' to be taken under Part B, subject to certain regulations. (See same reference.)

† Suspended during the war.

had a sound medical training and be good clinicians, and that they should, after qualifying, have had at least two years in which to gain clinical experience both in house appointments and in general practice. It then becomes necessary to offer three distinct types of training:

(i) For the man who is to devote his life to this type of work and who intends to become a consultant in it.*

(ii) For the man who intends to become an industrial medical officer, whether part-time or whole-time.

(iii) For special appointments.

* See R.C.P. Report, 'Industrial Medicine' (1945), p. 15.

(i) **For the Prospective Consultant.** For the prospective consultant a special type of training should be available. These men should hold studentships or fellowships in University Departments of Industrial Health where they should spend at least one year; they should have ample opportunity of seeing numerous industries and working in a factory for at least one year; they should also be enabled to meet men connected with various aspects of industrial activity—not necessarily medical. They would, during the tenure of their appointment, be occupied in field research, in travel and in certain types of teaching. Such men should have obtained the M.R.C.P.

(ii) **For the Whole-time Industrial Medical Officer.** The whole-time industrial medical officer should, if possible, devote three months to his training. It is realized, however, that there are many experienced and valuable men who could only take such a course if it were arranged on a part-time basis. So it seems essential that some educational facilities should be provided by **all** universities with a medical faculty. Refresher courses are of much importance, and form a fundamental part of any teaching programme. Part of the course would be of a practical nature and include visits to a wide range of industries, short periods spent in industrial medical departments, and sessions in both eye and skin hospital clinics.

A suggested outline of the points to be covered in a course for industrial medical officers is given as an appendix.

(iii) (a) **For Examining Surgeons.** Examining surgeons under the Factories Act are appointed to-day without any special training for their work because of the lack of facilities. The first essential for these doctors is a knowledge of general medicine, but this knowledge can only be put to its fullest use in industry by special training in the principles of job allocation, industrial toxicology, and workmen's compensation. Special courses are therefore necessary to supply this knowledge. These courses should last for two weeks and be given perhaps twice a year in a suitably placed University Department of Industrial Health. These courses would also be ' refresher ' courses, and examining surgeons already holding appointments would be well advised to attend them. This would be more likely if they were subsidized. Courses of this type would be comparable to those sponsored by the Ministry of Health for general practitioners.

The examining surgeon's course would deal with legal aspects of the work, industrial diseases and their early detection, and care of juveniles. Visits to factories would be arranged and their attendance at a good skin clinic insisted upon.

It is quite possible that in the future development of industrial medicine the examining surgeon may be given greater responsibility. If such a development occurs, more emphasis must be placed upon the training of these men for their work; satisfactory instruction would best be afforded by the ordinary course outlined in the appendix.

(b) **For Factory Medical Inspectors.** In future factory medical inspectors should at least have had the full course of the industrial medical officer. Better still, they should have held a studentship or fellowship at a University Department of Industrial Health. Such a training would be an excellent preparation for the work. The question arises, however, as to whether the salary and conditions offered at present by the Factory Department would attract men who had such a prolonged training. Under present conditions this is doubtful.

Training of Nurses

The education of nurses is of much importance in any industrial health plan. They are key workers in the service. More emphasis should be laid on the need for experienced industrial medical officers to take part in their training, and for it to become an important responsibility of University Departments of Industrial Health. The syllabus for such a course might well be based on that set out in detail in a recent article by Dr. A. J. Amor and Miss Clare Sykes.* In obtaining recruits for courses so far held in this country there has been no difficulty, because of the great increase in the number of nurses employed. The Royal College of Nursing has been the pioneer in this direction, and a tribute must be paid to their work in this field. The College has granted its own Certificate in Industrial Nursing since 1935.

A three months' whole-time course would be ideal, but would raise financial difficulties for many nurses, and with the present-day shortage of nurses is probably impractical.

In Birmingham the nurses work for a year at the Birmingham Accident Hospital as staff nurses and are trained in industrial subjects, the University granting a Certificate in Industrial Nursing after examination. Nurses already holding industrial appointments and nominated by their medical officer are also accepted for training.

Similar courses of training could well be arranged at other university centres, but it is desirable that there should be only one Certificate in the subject, granted by some central body representative both of nurses and industrial medical officers.

It might also be possible to offer part-time industrial training to staff nurses holding casualty or other appointments in any hospital in an industrial area. Part-time training along these lines would probably occupy 9–12 months. Experience shows that it is of the utmost importance to attract girls of a good general education to this branch of work. Those who have not this background find themselves incapable of taking advantage of the instruction given, and fail to make good industrial nurses.

Education of the Layman

Non-medical Personnel in Industry. In every factory, large or small, the works manager, technicians, foremen, and the workers themselves, and

* *Brit. J. industr. Med.*, 1944, **1**, 81.

particularly the personnel officer, all play some part in maintaining the health of the workers and preventing accident and disease. There is therefore a need for general education on health matters and this should be supplied by a University Department of Industrial Health. Manchester University has done this successfully for the past few years.

Hospital Personnel. It is to be hoped that eventually all teaching hospitals will have on their staff, or available to them, a good industrial medical officer to do some teaching on industrial medical subjects—just as at present many teaching hospitals have a general practitioner to give one or two lectures on the special nature of his work. Such a man could best undertake undergraduate teaching along the lines suggested in the Interim Report (1943) of the Social and Preventive Medicine Committee of the Royal College of Physicians. Detailed instruction on occupational diseases need not be given, but teaching would aim at providing knowledge and understanding of health and social problems relating both to industrial workers themselves, and to their environment. It would be a good thing if one senior member of the medical staff took a particular interest in the problems of occupational disease, just as the orthopaedic or accident department takes an interest in industrial injuries and their rehabilitation for local industry.

Almoner or Social Service Worker. The almoner is a most important link between the hospital and industry. She should have a much wider training in industrial subjects; at present these are dealt with only in their very broadest aspects in her original training. The practical training of the almoner in her own particular hospital, with its special industrial contacts, should be the responsibility of some specially appointed doctor with experience of industry, preferably a whole-time local industrial medical officer.

Diploma in Industrial Health

Although there are many arguments against an increase in the number of diplomas issued following study and examination in special subjects, from the trend of events in the establishment of a national health service, including a consultant service, it would appear that if industrial health is to be recognized as a special branch of medicine then a Diploma in Industrial Health will become a necessity.

A special committee of the General Medical Council on the registration of specialists has decided that it is desirable to have a register of specialists. They say that such a register will have to be available at the start of the national health service. The criteria for inclusion on such a register will initially depend on the fact that a man had acted as a specialist in the past and was generally recognized as a specialist by other practitioners in the area where he practised. Subsequently, the inclusion of specialists will depend on post-graduate qualifications and experience in the specialty concerned. The fact that a doctor had a Diploma in Industrial Health might assist employers and others in making appointments to posts.

This Committee holds the view that special medical diplomas have only a limited use. A diploma is not an inspiring stimulus to or an end of higher medical studies. The function of a post-graduate school of medicine is to provide opportunity for research and the training of specialists, and if such training is entirely centred on the acquisition of a diploma, the broader aspects tend to be excluded to the detriment both of the school and the graduate. It is important to recognize that, so far, the value of special medical diplomas has been small, except in the case of public health. The criterion for specialist or consultant in the teaching hospitals, and in many of the large provincial non-teaching hospitals, is experience plus the possession of either the M.R.C.P. or F.R.C.S. It is rare to find a consultant on the staff of a large hospital with a diploma in his specialty in addition to these qualifications, except perhaps in those branches of medicine which may be considered as ancillary or non-clinical, such as radiology or anaesthetics. Fundamentally those practising industrial health must have a sound clinical background. Factory experience and special lectures will be required during the introductory period for any new industrial medical officer. The possession of the M.D. or M.R.C.P. will always be desirable, even with a Diploma in Industrial Health. One useful addition to the examination for the M.D. and the M.R.C.P. might be the possibility of taking a special subject as an integral part of the examination, as occurs at certain Scottish universities and the Royal College of Physicians of Edinburgh, the special subject in this instance being industrial health.

Despite these criticisms of the principles of medical diplomas—with the exception of the D.P.H., the value of which is fully recognized—the Committee is of the opinion that the creation of a Diploma in Industrial Health is necessary in the immediate development of this new branch of medicine.

The Goodenough report (p. 231) recommends—again with the notable exception of the D.P.H.—that special diplomas should be given by the Royal Medical Colleges; thus satisfactory machinery could be set up to equate standards. The Committee agrees with this, and recommends that if a Diploma in Industrial Health is instituted it should be given by the Royal Colleges who would become the body responsible both for standards and examination.† It would not be in the best interests of industrial medicine if diplomas in the subject were instituted by separate universities or other bodies throughout the country.

† Dr. J. C. Bridge advocates that, if a Diploma is instituted, it should be a registrable qualification; in this case standards would be equated by the General Council of Medical Education and Registration, and any examining body would be free to institute its own Diploma.

Summary

1. From a survey of present industrial medical practice in different industries it can reasonably be concluded that there will be a continued demand for doctors and nurses in this field. Plans for education in industrial health must therefore be made at the earliest opportunity.

2. Present facilities for education in industrial health are quite inadequate; but with appointments of Professors and Readers in the Universities of Manchester, Durham and Glasgow now materializing there is good prospect of early improvement. Further appointments should be made at London, Birmingham and Liverpool Universities.

3. Medical undergraduate training in the principles of industrial health should be carried out in every medical school.

4. Medical post-graduate training should be available at universities in industrial areas for potential consultants in the field, for both whole-time and part-time industrial medical officers, for examining surgeons, and for medical inspectors of factories. Training should be by means of fellowships at University Departments of Industrial Health, whole-time courses of study, part-time courses, and refresher courses.

5. Training of nurses for industry is an important function of University Departments of Industrial Health. But one central body, representative both of nurses and industrial medical officers, should lay down standards of training and carry out examinations for the Certificate in Industrial Nursing.

6. There is need for education of laymen in industrial health, particularly for almoners or social service workers at hospitals and for other hospital personnel.

7. Although there are many arguments against an increase in the number of medical diplomas issued after a term of post-graduate study, it appears that a Diploma in Industrial Health has now become a necessity. The Diploma should be instituted solely by the Royal Colleges who would become the body responsible for standards and examination.

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APPENDIX

Outline of points to be covered in a Course for Industrial Medical Officers

A. Introductory

1. The structure of industry.
2. Development of health legislation and medical services in industry.
3. Functions of labour management, personnel and welfare services.
4. Trade Unions, industrial relations, wage agreements, joint production councils, etc.
5. Functions of an industrial health service and its relation to general practitioners, consultant and other health services.

B. General Principles of Social and Preventive Medicine

1. Infection.
2. Nutrition.
3. Environment.
4. Heredity.
5. Medical statistics.
6. Group sickness incidence and labour wastage in industry.
7. Planning of controlled investigations.

C. Organization of a Health Service in Industry

1. Relation to other managerial departments and workpeople within the industry.
2. Accommodation and equipment.
3. Staffing, including nursing staff.
4. Ancillary services, i.e. dental, ophthalmic, or chiropody.
5. Casualty service.
6. Administration.
7. Records.

D. Placement of Workers

1. The pre-placement medical examination.
2. Principles of vocational guidance and selection, the use and limitations of aptitude and intelligence tests.
3. Job analysis in relation to capacity for work.
4. Reinstatement on return to work after illness or injury.

E. Physiology and Psychology of Work

Muscular work, lifting, static strain, fatigue, and recovery; hours of work, rest-pauses, speed of work, night work, shift systems; physiological aspects of machine design, seating and arrangement of benches; monotony, boredom and incentives; health aspects of time and motion study.

F. Working Environment

1. Heating and ventilation.
2. Atmospheric pollution and its control.
3. Lighting.
4. Occupational causes of physical disability and their prevention.
5. Sanitation. Washing and sanitary accommodation; facilities for accommodating and drying clothes; general cleanliness; overcrowding; drainage of floors, etc.

G. Industrial Accidents

1. Causes.
2. Statistics.
3. Prevention.
4. Treatment.

H. Occupational Diseases

Etiology, prevention and treatment.

J. Rehabilitation and Resettlement in Industry

1. Rehabilitation of sick and injured workmen.
2. Resettlement and retraining.
3. Legislation.

K. Special Problems related to Employment of Women and Young Persons

L. Industrial Health Legislation

Factories Act, Mines and Quarries Act, Social Insurance, Disabled Persons (Employment) Act, etc.

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EDUCATION IN INDUSTRIAL HEALTH

The crux of the Report of the Royal College of Physicians of London on Industrial Medicine is the argument for a National Industrial Health Service, and the members of the committee responsible for the Report were much concerned with the training of the medical officers of this service. That training has now been considered in greater detail by the Education Committee of the Association of Industrial Medical Officers, and I am glad of an opportunity of giving a warm welcome to the report published in this issue.

The very existence of this country as a first-class power depends on the development of industry after the war. The mills admittedly grind slowly, but to anyone who has been concerned with the training of the medical profession for many years, as I have been, it is plain that it is to education that we must look for the ultimate solution of the many problems involved.

As the College Report emphasized, full efficiency in industry can only be achieved by contented producers, and such contentment implies the highest attainable level of physical and mental health. This in turn will demand the fullest co-operation of employers, workers, and all members of the medical profession. It is with the training of the last that the present report is concerned, and it covers the whole field of undergraduate and post-graduate education, not forgetting the training of nurses and the education of the layman. It is satisfactory to learn that the undergraduate is not to be burdened with yet another major subject. The suggestions for lectures and demonstrations are modest ; it is more important that the ' teachers of medicine and surgery should themselves understand something of the principles of industrial health ' that it may be part of their everyday instruction.

The College Report did not reach any final conclusion concerning a Diploma in Industrial Health, but the decisions of the Association's Committee seem to me wise, with their insistence on its limited use and on the broader aspects of post-graduate training in industrial health to secure a sound clinical background and to foster every opportunity for research. In the light of these decisions, it will obviously be the duty of the Royal College of Physicians at an early date to consider the establishment of a Diploma. Such action, if approved, would probably provide a useful stimulus to the development of more adequate facilities for education in industrial health. These facilities would then become more widely available not only for a Diploma course, but also for training the part-time industrial medical officer and for the more advanced study necessary for the industrial consultant. In the words of a famous historian: ' The transitions of industry are always painful,' and it may well be that a painful phase faces this country no matter what political party is in control. It is the duty of the medical profession to equip itself to relieve pain and suffering, and in the industrial field the Association of Industrial Medical Officers has set out clearly how this may be achieved.

MORAN.

INTERNATIONAL INDUSTRIAL MEDICINE

Since the last century Great Britain has amassed an extensive knowledge of industrial medicine and hygiene, both through its Government services and industrial medical officers and others working independently of state organizations. The industrial revolution came first in the old world to Great Britain, whose inhabitants had no precedents to guide them in safeguarding the health of work-people. Legislation to protect workers was developed as a result of the efforts of reformers, enlightened employers and trades unionists. At the beginning of the last century it was narrow in its scope and not rigidly enforced. But to-day the Factories Act and other Acts and regulations protect all who work in factories and mines, and are enforced by His Majesty's Inspectors who observe and record the effects on safety and health of many different types of work and conditions. This legislation bears comparison with that of any other county in the world, as does the means of enforcing it. In peace-time the knowledge collected by the Factory and Mines Inspectorate has to some extent been made available to other countries through the International Labour Office. This body, unlike the International Health Organization, survived the shipwreck of the League of Nations. It has two principal duties: the drafting of conventions and recommendations to Governments with the object of protecting the health of workers throughout the world, and the collection and dissemination of information on industrial health which is likely to be of international interest. More than thirty international conventions have been concluded and ratified by states large and small. There are those relating to the use of white lead for example, and to compensation for occupational diseases; in addition detailed recommendations have been submitted to Governments on the protection of the worker against anthrax, white phosphorus and lead poisoning. The International Labour Office has also maintained a continuous review of industrial medicine and hygiene published under the name of ' Occupation and Health'.

Before the war the International Labour Office arranged every four years a World Congress on Industrial Accidents and Occupational Diseases. These Congresses should be revived after the war

and the invaluable work of this body should be actively supported by all countries who subscribe to the principles of world security against war and disease. This year, at the San Francisco Conference, delegates on the Committee on Economic and Social Co-operation suggested the establishment of a new Industrial Health Organization which would centralize and co-ordinate existing bodies such as the Pan-American Sanitary Bureau, the Office Internationale d'Hygiene Publique in Paris, and any remnants of the League of Nations Health Organization. This proposal made by delegates from China and Brazil was warmly supported by representatives of many countries, including the United Kingdom, the U.S.A. and the U.S.S.R. Nevertheless there are obvious advantages in the International Labour Office acting as the co-ordinating body for industrial medicine and hygiene. It has done excellent work in the past and during the present war. The new International Health Organization will have urgent work to do in the control of epidemic diseases and in the relief of nations ravaged by war and other disasters. There should be close co-operation between these two organizations, for industrial medicine is but one facet of international preventive medicine.

Medical officers in their own organizations are able to study in detail many of the health problems associated with their industries. They have an approach to industrial health which differs in some respects from that of those in Government service who are primarily concerned with legislation and its enforcement; so there should be a free channel of communication between nations peripherally as well as centrally. This need has been appreciated by the Association of Industrial Medical Officers, which has appointed a special committee to establish and to maintain relations with medical practitioners in the British Commonwealth of Nations and in foreign countries engaged in the practice of industrial medicine and hygiene, including teaching and research. This Foreign Relations Committee will need time to consider and deliberate on its duties, but there are many problems which demand immediate attention. In the past contact from outside has been difficult because of the absence of well-defined points at which research and training in industrial health subjects could be centred. This difficulty should disappear after the war with the foundation of University Departments of Industrial Health. These centres will act as foci towards which visitors to this country will be drawn and from which contacts can be made with similar departments abroad. Relationships abroad will be fostered by the granting of travelling fellowships to those who are to teach and carry out research, and the far-sighted policy of the Nuffield Foundation in stimulating foreign travel as an essential part of the fellowships which they recently decided to endow will be of great value. There should be a central Institute of Industrial Health in London with a central library of industrial medicine and hygiene, through which medical officers and others could refer to foreign work and, if necessary, be introduced to and make direct contact with industrial medical officers and hygienists in other countries. Contact through the written word is essential and probably the first need, but it must be cemented by visits of medical officers in Great Britain to other countries and by welcoming in this country medical officers from overseas who should be offered every facility to meet members of the Association of Industrial Medical Officers and to see British industry and its medical services.

As the circulation of this JOURNAL widens it may be advisable to invite eminent industrial medical officers from the Dominions, Colonies and foreign countries to be members of its Editorial Advisory Board. As a country we have learnt many lessons, but we still have much to learn from our colleagues abroad; and by this interchange of information between Governments and unofficial ambassadors of nations much can be done to improve measures for the maintenance of the health of workers throughout the world and thus to add to its wealth.

TRICHLORETHYLENE

Trichlorethylene is a chlorinated hydrocarbon of the aliphatic series. It is a colourless liquid with a characteristic smell. It has been known in industry for at least thirty years, being used for degreasing metals, in the extraction of oils and fats, in painting, enamelling, dyeing and dry cleaning; in the boot and shoe industry; in textile manufacture and the printing industry; as an insecticide, a disinfecting agent, and an impregnation material; in cleaning films, photographic plates and optical lenses; in the chemical industry; in gas purification; and as a rubber solvent. During the last ten years it has been used in the practice of medicine as an anaesthetic under the name of trilene. It has also been used in the treatment of trigeminal neuralgia and angina pectoris. It differs from other chlorinated hydrocarbons, and in particular chloroform, by not producing any severe lesion of the liver or kidneys in experimental animals; only Mayer,[1] Castellino,[2] and Lande [3] have reported any changes in these organs. Bridge [4] and Wilcox [5] have each recorded the occurrence of jaundice in a man exposed to trichlorethylene, but in neither case was there any evidence that it could be attributed to this compound.

Dermatitis caused by trichlorethylene presents no special features. It is produced, as is the case with all fat solvents, by dissolving the protective fatty layer, and thus lowering the resistance of the skin to conditions of excessive warmth or moisture. In industry, however, the chief danger has been that of acute narcosis following prolonged exposure to high concentrations. This can easily prove fatal if

1 *Klin. Mbl. Augenheilk*, 1929, **82**, 309.
2 *Folia med.*, 1932, **18**, 415.
3 *Arch. Mal. profess.*, 1939, **2**, 454.
4 Ann. Rep. Chief Inspect. Fact. for 1932 ,107.
5 *Proc. roy. Soc. Med.*, 1933, **27**, 455.

the worker is alone and is not observed by his colleagues, especially as the vapour is heavy and therefore tends to accumulate near the floor. Stuber [1] has reported 117 cases of unconsciousness in workers in German factories, of whom 12 died, and this occurrence is not uncommon in England. Between 1933 and 1943, 203 cases were reported to H.M. Chief Inspector of Factories, and of these 10 were fatal. It is clear, therefore, that when solutions containing trichlorethylene are used in closed chambers, the men should work in pairs and relieve each other at frequent intervals. The man in the enclosed space should be provided with a life-belt and also an apparatus through which he can breathe air from outside. Baader [2] observed that continued exposure to low concentrations caused a pleasant feeling of mild intoxication which may lead to a craving for further exposure, and obviously this must be prevented. In contact with a naked flame trichlorethylene can be oxidized with the formation of phosgene, and the suggestion is sometimes made that the toxic effects are due to this breakdown product, but in practice it is doubtful whether the harmful effects can ever be attributed to phosgene.

As early as 1916 Plessner [3] reported that patients suffering from chronic trichlorethylene poisoning showed bilateral paralysis of the fifth nerve; and since then German factory inspectors have described corneal ulcer resulting from a foreign body in the eye, the workmen not having been aware of its presence because of anaesthesia of the cornea. Of Stuber's 284 cases, 10 showed fifth nerve paralysis and 9 optic disturbances. These included blindness from optic atrophy in two, and retrobulbar neuritis with disturbances of the colour field in the others. Isenschmid and Kunz [4] described the case of a man who, after exposure to the vapour of trichlorethylene in cleaning steel cylinders, developed retrobulbar neuritis, left-sided paralysis of his tongue, and polyneuritis of all four limbs. It has never been understood why these cranial nerve palsies have occurred so frequently in German industry, and yet no case has ever occurred in Great Britain. Jackson [5] has pointed out that no local paralysis resulted from the treatment of trigeminal neuralgia with trichlorethylene. He therefore suggested that these palsies were due to some other poison and not trichlorethylene itself. Last year, however, much light was thrown on this problem by Humphrey and McClelland [6] and Carden [7] who reported seventeen cases in which cranial nerve palsies, sometimes with herpes, developed after general anaesthesia. In two of the cases reported by Humphrey and McClelland the patient died, and since then several more fatal cases have occurred. All the patients were anaesthetized with a closed circuit apparatus but several of them did not receive trilene. However, it was known that trilene had previously been used in the apparatus, and thus the notorious reputation of trichlorethylene in Germany led to its being suspected as the noxious agent. In this issue of the JOURNAL Powell has demonstrated that part of the trichlorethylene absorbed by the human body is oxidized to trichloracetic acid, and derivatives of this compound have been prepared from urine. But there is no evidence so far that trichloracetate or its precursors produced in the metabolism of trichlorethylene are toxic. However, the phenomenon is of considerable interest and might be applied as the basis of a simple urinary test for undue exposure to trichlorethylene in industry. Cox [8] and Milton [9] showed that when trichlorethylene is passed over soda lime dichloracetylene is formed; a reaction which is greatly stimulated by rise in temperature in the soda lime and therefore occurs briskly in those soda limes containing a high percentage of caustic soda. Milton and his colleagues also showed that rats exposed to a trilene-dichloracetylene mixture for 30 minutes died in convulsions, whereas a control group exposed to trilene alone recovered. It is tempting to attribute the peculiar anaesthesias observed during the industrial use of trichlorethylene as described by German authors to the presence of impurities or to decomposition products, but there is no certain evidence as to what these might have been. Prevention of contact of this solvent with caustic alkalies is the practical lesson to be learnt from recent experience.

[1] *Arch. gewerbepath. u. hyg.*, 1931, **2**, 398.
[2] *Zbl. Gewerbehyg.*, 1927, **4**, 385.
[3] *Klin. Wschr.*, 1916, **53**, 25.
[4] *Schweiz. med. Wschr.*, 1943, **65**, 530.
[5] *Anaesth. Analges*, 1934, **13**, 198.
[6] *Brit. med. J.*, 1944, **1**, 315.
[7] *Ibid.*, 1944, **1**, 319.
[8] *Brit. med. J.*, 1944, **1**, 317.
[9] *Ibid.*, 1944, **1**, 341.

OPHTHALMOLOGY IN THE FACTORY

BY

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Since vision is the dominant sense in man and since the majority of industrial processes are visual, it follows that ophthalmic questions are constantly arising in factory work. On entry, the problem of ocular fitness for the contemplated job should be considered; once the job has started the conditions of illumination are of importance, as is the problem of time lost from eye strain, which might have been prevented by the provision of adequate optical aids. Certain jobs carry certain eye risks, either of accident or of disease, and means of reducing these must be evolved. Their treatment, should they occur, is of importance. It must also be remembered and reiterated that a worker may suffer from an eye disease having no connexion with his work and that loss of time may, in many instances, be avoided by early diagnosis. Finally, should an accident or industrial disease occur, the questions of compensation, of traumatic neurasthenia and of rehabilitation, re-training and re-settlement will have to be dealt with.

The eye can be regarded from two aspects, either as an optical instrument or as a living organ. From the first point of view, it is often imperfect, but can be rendered efficient by mechanical means. From the second point of view, it can participate in general diseases of the body or can itself become diseased, showing, like any other tissues, changes which may be traumatic, inflammatory, neoplastic or degenerative. Finally, it must be realized that examination of an eye which is itself not producing symptoms, may lead to diagnosis of important disease in other organs, for example, the brain, pancreas or kidney. It is therefore obvious that examination of the eyes of factory workers at any stage should be carried out by an ophthalmic surgeon rather than by a non-medical refractionist, though the latter might very profitably work under the supervision of the former in order to save time. Since about 98 per cent. of the population show some error of refraction it is obvious that it is not necessary to correct every error that is found. The additional medical knowledge which the ophthalmic surgeon possesses over the refractionist enables him to assess the relation between the symptoms and the refractive error and so to decide whether spectacles are necessary in a given case. Many persons, for example, show a low grade hypermetropic astigmatism. If they are young, healthy, and have good binocular balance there is no need to correct the error, though the same error occurring in a person of middle age employed on fine work would seriously handicap him and would necessitate spectacles. Conversely, a low grade myopia is an advantage in middle age and even in young persons often need not be corrected. Figures given by Kuhn [1] for occurrence of visual defects in industry are: defects in visual acuity 33 per cent., in depth perception 16 per cent., in colour perception 5 per cent., and in muscle balance 22 per cent. This was based on 16,332 examinations of workers already in jobs. Not all of these, of course, need treatment, though many would be improved by it.

On entry into the factory, the workers should, ideally, have an eye examination which should include a test of visual acuity with and without correction of errors of refraction, a test of binocular balance and range of accommodation, an examination of the fundus and a rough estimate of the field of vision. In this way one will gain an idea of the type of work which can be undertaken and will avoid the obvious pitfalls of putting uncorrected presbyopes on to precision or clerical work, or myopes on to long-range jobs. Such counsel is that of perfection and may well be unattainable. Even if, however, a full test cannot be carried out an attempt should be made to test the acuity *at the distance of the proposed job*. Some factories, following the example of the Royal Navy and the railways, give a 6-metre test only and consider that a visual acuity of 6/36 or 6/60 is undesirable, in spite of the fact that, if it is caused by a low grade myopia, it may well be an advantage in precision work. This led, not so long ago, to the naïve statement by an American factory that they were surprised to find on analysis that the men with the worst visual acuity for distance did the best fine work and complained the least of eye strain. A recent investigation [2] of a group of workers on a very close job (spiral filament inspection) brought out the fact, long suspected by ophthalmologists, that perfect binocular balance at the near point is of more importance in the avoidance of eye strain than is perfect correction of refractive errors. The mere provision of spectacles will, therefore, do little to relieve the precision worker, since routine correction of refraction will lead to anomalies such as correction of low grade myopia in early middle age, or correction of hypermetropia in young exophorics with convergence deficiency. It is better to be entirely monocular than imperfectly binocular, a fact which may account for the almost universal adoption of the watchmaker's monocular loupe rather than any binocular device of similar power but more difficult adjustment. When, however, an individually prescribed binocular loupe can be obtained, greater comfort and often improved visual acuity will ensue owing to retention of binocular vision and depth perception. In some trades, however, the magnification required may be too great for comfort with a binocular loupe and a short monocular working distance with a higher magnification may be found preferable. Each job should be separately studied and visually assessed. It is quite possible by a study of the requirements of the job and of the worker's eyes to prescribe in every case (disease apart) a suitable optical instrument, monocular, binocular, or bifocal and prismatic, to enable him to do that job in comfort. This type of prescribing requires ingenuity and a study of conditions on the spot. It has been tried in the United States of America and advocated and described in Kuhn's book on industrial ophthalmology.

In addition to his individual industrial prescribing, the ophthalmologist should satisfy himself that the con-

* A post-graduate lecture given at the London School of Hygiene and Tropical Medicine on May 13, 1945.

[1] *Industrial Ophthalmology*. The C. V. Mosby Co., St. Louis, 1944.

[2] Mann, I., and Archibald, D. (1944). *Brit. med. J.*, **1**, 387.

ditions of illumination are satisfactory. Glare should be avoided, shadowless lights should not be used where grain and texture are to be observed, fluorescent tubes are often unsuitable if the work entails rapid side to side movements and there should never be too great a contrast between the illumination of the work and of the rest of the room.

The question of periodic eye examination while on the job now arises. Should the factory be responsible for this, as the railway companies already are? The answer is that it should be responsible if possible, since we know that latent hypermetropia becomes slowly manifest and a job suitable for a hypermetropic boy may lead to eyestrain at 30 if he is not given glasses at the right time. The age of onset of presbyopia varies slightly and is, of course, greatly altered by the initial refraction, but on the whole one can say that a sight test every three or five years would save a fair proportion of discomfort. Annual tests, obvious disease apart, are not necessary, but certain insidious diseases such as glaucoma, may be missed in the later age groups if the interval is too long.

Having put and maintained our workers in the best conditions to do the job, we must now deal with industrial risks, such as risks from flying particles, risks from chemical fluids and vapours and risks from irradiation. Here again the aim should be prevention. Possibly the greatest ophthalmic need in industry to-day is the production and popularization of a comfortable and efficient protective goggle and the establishment of a 'goggle maintenance service,' such as is used in certain American factories. The problem has been grossly neglected in this country, and the number of minor eye injuries, which are preventable, is very great.

If the injury has not been prevented, we are faced with its treatment. If a foreign body is small and superficial it can be dealt with by a nurse (provided she has worked in an eye hospital) or by the factory doctor. It must be carefully removed with the minimum of damage. The question of prevention of sepsis is one which is receiving much attention at present. Experimental work points to sulphonamide or penicillin as the best prophylactic, but it is not yet certain that either is of any use as a single application. The present 'factory' eye drops (containing cocaine and hydrarg. perchlor. in castor oil) are of doubtful value and if misapplied may do harm. They usually produce intense discomfort.

Patients with more serious injuries should be sent to hospital. Small inconspicuous wounds of the cornea in which the foreign body cannot be seen are the most dangerous, as they probably mask an intraocular foreign body. Injuries in the ciliary region and to the lens are the most serious. All patients with injuries suspected of perforating are surgical emergencies and must be sent to an eye hospital at once.

The industrial eye diseases peculiar to the factory involved should, of course, be especially studied by the medical officer. Such things as welder's flash, chemical burns, reactions to irritants, and 'fumed eyes' in viscose factories, all require their special prophylaxis and treatment. Welder's flash is a superficial radiational burn of the corneal epithelium. It is not apparent at the moment it happens and perhaps more often results from the striking of an arc by someone other than the patient, since all welders, after one experience, are careful to protect themselves from their own arc. The symptoms are an intense irritation, lacrimation and pain coming on about six hours after exposure. If this is in the night the patient will be awakened by the pain. If it comes on during working hours drops of cocaine and ephedrin are indicated for the relief of pain. Healing is usually rapid.

Chemical burns are more serious. Acid burns on the whole recover more quickly and leave less disability than do alkali burns, which lead to intense oedema and may take months to subside. Other more complicated substances may cause ocular injury by splash or vapour, such as the various materials used in chemical warfare. Various types of acute and chronic keratitis can be recognized, as, for example, that caused by di-chlorodiethyl sulphide (mustard gas). This produces in severe cases a vascularizing keratitis which partially recovers and is then subject to repeated re-ulceration, even many years after the exposure. Injuries by di-vinyl arsine on the other hand give destructive lesions which once healed do not break down. Specific antidotes to be applied at once exist for some compounds, but copious irrigation with a large volume of water is often of great value as a first aid treatment.

In some trades there is a specific risk, for example, 'fumed eyes.' This is found in viscose workers in factories manufacturing 'silk' stockings where the worker is inadequately protected from the microscopic spray (probably of varying concentrations of H_2SO_4) shaken from the spun thread as it leaves the spinning bath to be wound on the spindle. The symptoms, discomfort and the appearance of coloured haloes round lights, are caused by a fine oedema of the superficial cells of the corneal epithelium. This disappears in a day or two if the worker is not further subjected to the spray. Other processes carry a long term risk, such as the risk of cataract in glass blowers and chain makers, or of nystagmus in miners. Both these conditions are largely preventable, the former by the use of Infrex or other glass goggles which cut out infra red rays, the latter by more efficient illumination and improved conditions in the mines.

We must now return to the question of the occurrence of non-industrial eye disease in the factory. Prompt attention to any red or painful eye may save much lost time from iritis or glaucoma and early recognition of contagious conditions (e.g. Koch-Weeks conjunctivitis and epidemic kerato-conjunctivitis) may save spread throughout a shop or the whole factory. Differential diagnosis between acute conjunctivitis, acute iritis and acute glaucoma may save many serious complications. It is, however, a difficult diagnosis to make without the help of an ophthalmic surgeon. It is always better to suspect iritis or glaucoma when it is not present than to miss it when it is. An acute iritis treated promptly (the first day) with atropine will often be well in a week or so, but if neglected (i.e. treated as a conjunctivitis) for a week may necessitate admission to hospital, operation, and prolonged or even permanent disability. A wrongly-treated glaucoma involves an even greater risk to the patient.

The question of general disease affecting the eyes of workers is also of importance. For example, a large number of cases of diabetes are diagnosed in the first instance in eye hospitals, where the patients have come for a change of glasses. Albuminuria, arterio-sclerosis, cerebral tumour, various vitamin deficiencies and anaemias, as well as syphilis, tuberculosis and sarcoidosis have definite diagnostic eye signs, often in stages where there is little or no general disturbance. Periodic examination of workers would detect a certain number of these.

That the factory ophthalmic service shall be as efficient as that outlined here is probably a counsel of perfection, but factory doctors with partial training in ophthalmology can do much by careful selection of cases for further opinion and examination.

REVIEWS

TREATMENT OF SHOCK

Medical Research Council. War Memorandum No. 1: The Treatment of ' Wound Shock.'

(H.M. Stationery Office, London. 1944. 2nd Ed. Pp. 32. 6*d*.)

A number of different conditions due to different sorts of trauma are comprised in the term ' shock,' and throughout the memorandum, now in its second edition, the indefinite connotation of the term is emphasized by the use of inverted commas.

Severe limb wounds and burns bulk large among causes of ' shock ' and, since their initial mortality is lower than, for example, severe visceral injuries, they have provided the material for most of the investigations of ' shock.' In ' shock ' due to limb wounds and burns oligaemia, due to loss of blood or plasma externally or into the traumatized area, is regarded as the most important etiological factor. Loss of blood, if amounting to 25 per cent. or more of the total blood volume, can produce signs of ' shock '; low blood pressure; poor, rapid, pulse; pallor or cyanosis, and sweating; and vomiting. Similar symptoms may follow the loss of smaller quantities of blood in susceptible people, and if the blood loss is accompanied by pain or occurs when the subject is in an upright position vaso-vagal collapse ensues. It is also to be noted that a low blood-pressure is not invariable, and the severity and nature of the injury may often be a better guide to the diagnosis of ' shock ' and to the need for transfusion than the blood-pressure. Haemoglobin estimations in the early hours of ' shock ' due to haemorrhage are of no value as an index of blood loss since the restitution of the blood volume by dilution with tissue fluid takes some hours.

In burns it is thought that the ' shock ' is due to increased capillary permeability in and around the burn leading to transudation of plasma and to haemoconcentration; haemoglobin estimations are therefore of value in assessing the degree of ' shock ' in burns. In injuries involving the crushing of large amounts of muscle, ' shock ' may follow the release into the circulation of the diffusible constituents of necrotic muscle, and in such cases there is frequently renal failure. Other complications of wounding that may lead to symptoms of ' shock ' include fat embolism, inhalation of toxic gases, infection, anaesthesia, and dehydration.

In the treatment of the ' shocked ' patient there are three main aims: arrest of haemorrhage, restoration of blood volume, and removal of damaged tissue. The operation should be carried out as soon as possible and resuscitation measures may often be best carried out in the operating theatre immediately prior to surgical treatment. Haemorrhage is most satisfactorily controlled by local pressure dressings; the injured part should be well immobilized. Morphine, $\frac{1}{6}$ grain intravenously, may be given to relieve apprehension. Copious drinks should be given. Transfusion is the only measure that will save life in the severely ' shocked ' patient. If the systolic blood pressure is below 90 and the pulse is rapid, transfusion should not be delayed. In other cases the decision may be more difficult, but it is better to give than to withhold transfusion, and the presence of a large mass of injured tissue in a limb, even though the blood pressure is normal, is often a definite indication for transfusion. Blood is the transfusion fluid of choice when the ' shock ' is due to blood loss; plasma or serum should be used for patients with haemoconcentration.

In both limb injuries and burns a transfusion may be enough to bring the patient out of ' shock ' and yet leave him very liable to relapse later, e.g. at operation. Adequate amounts of fluid should therefore be given. The transfusion of too much fluid, however, may lead to pulmonary oedema, as may transfusion in patients with trauma to the lung—thermal or toxic. Oxygen is only indicated in patients with pulmonary oedema or some interference with respiratory oxygen intake.

R. E. O. W.

HEALTH RESEARCH IN INDUSTRY

Proceedings of a Conference on Industrial Health Research held at the London School of Hygiene on September 28th, 1944.

(H.M. Stationery Office, London. 1945. Pp. 27. 6*d*.)

It cannot be denied that between the wars industrial health research failed to attract the interest it deserved. It was neglected by industrialists and Trades Unions alike and so was denied the place it should have held in an industrial community. In 1942, however, the Industrial Health Research Board was reconstructed and its terms of reference revised; the result has been a welcome change in attitude. The Board now accepts the view that it must serve industry, and that to do so it must keep in close contact with it. So a conference was convened by the Board and was a highly successful attempt to bring employers and Trades Union officials into its councils.

The report of the conference is of much interest. A stimulating account of the work of the Department for Research in Industrial Medicine at the London Hospital is given by Dr. Donald Hunter; he illustrates the part to be played by similar departments in the prevention of illness resulting from the exposure of the worker to toxic hazards. Lord Forrester speaks for employers, and deals with some of the more general health problems of industry. He touches on posture, on sickness records and on working time. It is important to look further than the hours per week; we must think rather in terms of hours per year. More attention should be paid to the location of industry; this he regards as within the province of industrial health research. He lays great stress on the need for dissemination of information on health matters to workers and management alike, but this must be presented in an effective and readable form. The point of view of the Trades Unions is given by Mr. Isaacs; and if undue stress appears to be laid on the prevention of industrial diseases it must be remembered that the attitude of the Trades Unions has been determined by their long fight to have certain of these diseases included in the schedule of the Workmen's Compensation Act. Mr. Isaacs, however, does not by any means confine himself to the narrower issue, but develops the thesis that research into problems of industrial health can pave the way to some of those freedoms expounded in the Atlantic Charter. Dr. Craik, Director of the Unit for Applied Psychology at Cambridge, briefly outlines the post-war programme of his department, and shows the need for confirming the consistency and validity of the tests which have been evolved for allocating the man to the job. The importance of the application of the results of research to industrial practice is rightly stressed by the Secretary of the Medical Research Council, Sir Edward Mellanby. He says that ' research work can only be a spearhead, and a spearhead without a shaft and without some one to hurl it is no good whatever '. He goes on to say that ' it is up to employers and to the Trades Unions to play their part and to see that these spearheads are not allowed to lie about as litter, but are fashioned into effective implements and so hurled as to do their job and maintain industry at the highest level of efficiency and to provide us with healthy and contented workers '. R. E. L.

ABSTRACTS

INDUSTRIAL MEDICINE IN SPAIN

Curso de Higiene del Trabajo (A Course of Lectures in Industrial Hygiene). Edited by PRIMITIVO DE LA QUINTANA (Jefe provincial de Sanidad de Madrid) and JUAN DANTIN GALLEGO (Jafe de la Sección de Higiene Industrial de la Jefatura provincial de Sanidad de Madrid). First Volume. Madrid (1944). Pp. 620.*

de la Quintana, P. ' *Prólogo* ' (Preface)

In this short foreword the author suggests that the next International Congress on Industrial Accidents and Occupational Diseases should meet in Spain. The last one, which met in Brussels in 1935, decided that the next meeting was to be held in Spain in 1939. It was also decided to hold an extraordinary Congress in Rome in 1937. Owing to the Spanish civil war and the death of Professor Devoto both meetings were suspended and the eighth and last Congress was held in Frankfurt in 1938. The author emphasizes the importance of the creation of the new National Institute for Occupational Medicine and Hygiene and he believes that the present publication will be a fresh stimulus to activities in that field.

I. *de la Quintana, P., Dantin Gallego, J.* ' *Introducción*,' p. 1–33. (Introduction).

The authors give an account of the historical evolution of industrial hygiene since its earliest development. Extracts from Spanish law relating to the work of natives in America during the colonial period are also given. Speaking about the institutions working at present throughout the world on industrial hygiene and related subjects, they give the names of those in Spain and the date of their creation: ' Instituto de Reeducación de Invalidos del Trabajo ' (1922), ' Instituto Nacional de Psicotecnia ' (1927), ' Clinica del Trabajo de la Caja Nacional de Seguros de Accidentes del Trabajo ' (1933), ' Sociedad Española de Medicina del Trabajo ' (1933–1934), ' Sección de Higiene Industrial y del Trabajo del Ministerio del Trabajo ' (1934).†

The introduction ends with a short review of the relation between some important diseases and modern industrial life. As regards cancer the authors remark that its incidence increases proportionally with industrial development, and that occupational forms of cancer exist like those found in chronic arsenic poisoning and amongst people working with x-rays, by-products of coal and chromates. Speaking about tuberculosis they show that the incidence of the disease is higher in industrial areas than in rural districts; they quote some results from the paper of Sánchez Alastruey on ' The influence of industrial development upon the incidence of tuberculosis in Vizcaya '.‡ He examined 1332 school children, boys and girls, between 4 and 16 years from the neighbouring towns of Baracaldo and Guecho (province of Vizcaya). The chief results were as follows:

	Total per cent.
Baracaldo (industrial town)	2·01 T.B.
Guecho (fishers, peasants, tradesmen) ..	1·01 T.B.

* Translation by Dr. Julian de Zulueta, Trinity Hall, Cambridge.
† National Institute for the Occupational Re-education of Invalids. National Institute of Psychological Selection. Clinic of Labour of the National Insurance Association for Accidents of Labour. Spanish Society of Medicine of Labour. Section of Industrial and Labour Hygiene of the Ministry of Labour.
‡ *Arch. Med. Cirug.*, Feb. 15, 1935.

II. *Olivares, L.* ' *El porvenir de la Higiene y la Medicina del Trabajo en España*,' pp. 35–47. (The future of industrial medicine and hygiene in Spain.)

This is the inaugural lecture of the course. The author, Professor of Surgery in the University of Madrid, says himself that he is not a specialist on the hygiene of labour. The paper therefore is not very important from a technical point of view.

III. *Dantin Gallego, J.* ' *El trabajo femenino—Capacidad de trabajo de inválidos, tarados y enfermos. Ambiente urbano y rural en Higiene Industrial. Profilaxis general y primeros cuidados a los intoxicados y enfermos profesionales*,' pp. 49–67. (Female Labour—Capacity of work of the disabled, those suffering from handicaps and those diseased. General urban and rural conditions from the point of view of industrial hygiene. General prophylaxis and first aid for industrial poisoning and diseases).

The author discusses pregnancy and other female conditions which make female labour difficult. In general he advocates: suppression of night work for women; shorter daily work; barring women from heavy and dangerous types of labour and compulsory rest before and after childbirth. On examination about 30 per cent. of industrial workers have some chronic disease, toxic condition or malnutrition, although they are apparently in normal health. These workers are necessary for a country's industrial life, but industrial hygiene has to determine the kind of work suitable for them. The paper ends with a few general remarks about life in towns and rural areas from the point of view of industrial hygiene, and with a short survey of emergency methods of treating industrial diseases and cases of poisoning.

IV. *de la Quintana, P.* ' *Fisiología del trabajo muscular fatiga y su profilaxis—Organización científica del trabajo*,' pp. 69–111. (Physiology of muscular work—fatigue and its prevention—scientific organization of labour.)

After considering the physiological, mechanical and biochemical aspects of muscular work, the author reviews methods for measuring industrial fatigue. He believes that a great part of this phenomenon is purely psychological and therefore difficult to measure. The ordinary fatigue tests and the apparatus used are described.

V. *Dantin Gallego, J.* ' *Tipificación de técnicas para el estudio colectivo de la higiene industrial*,' pp. 113–133. (Standardization of techniques for a collective study of industrial hygiene.)

Several aspects are considered here: public health statistics, techniques for a general study of occupational diseases, techniques for examination of sanitary conditions in workshops, classification and description of preventive measures, a critical review of preventive methods and techniques. On pp. 122–123 and 131–132 are reproduced the ordinary files used in the section of Industrial and Labour Hygiene (Jefatura Provincial de Sanidad—Madrid) for individual examinations and workshop surveys.

VI. *Ibarroloa Monasterio, R.* ' *Orientación y selección profesional desde el punto de vista higiénico industrial*,' pp. 135–148. (Methods in industrial hygiene: direction to and selection of occupations.)

The author reviews here the tests used for occupational

selection and for measuring the aptitudes of workers. He believes that the term 'psychotecnic' (in Spanish, psicotecnia) introduced by Stern, is employed to-day over a much wider field than its etymological meaning would suggest.

VII. *Ibarrola Monasterio, R.* '*Los accidentes y enfermedades producidos por los cambios de presión en el ambiente de trabajo*,' pp. 149–170. (Occupational accidents and industrial diseases due to changes of atmospheric pressure.)

This paper includes a short study of the physiology of respiration and accidents due to low pressure (high mountains, high altitude flying) and those due to an increased atmospheric pressure (divers and workers under the water). In both types true occupational diseases can develop.

VIII. *Garrote Vega, M.* '*Algunos conceptos de Medicina Aeronáutica de interés en Medicina de Trabajo*,' pp. 171–207. (Some aspects of aeronautic medicine of interest to industrial medicine.)

Most of the contents of this paper are not closely related to industrial hygiene. The author describes the necessary care, nutrition, etc., of flying personnel and specially of army air crews. He shows recent advances in that direction that he was able to observe while travelling recently in Germany. As regards occupational diseases amongst flying personnel, he believes that 'accelerations' (the so-called 'g's') are capable of producing lesions of the circulatory system, and that permanent changes in blood pressure may arise from high altitude flights.

IX. *Crespo Alvarez, A.* '*La cura de trabajo en los tuberculosos*,' pp. 209–238. (Occupational therapy in cases of tuberculosis.)

Rest is one of the general principles in the treatment of tuberculosis, but sometimes the rest need not be absolute and periods of repose are combined with periods of work. The cases of tuberculosis which can do useful work are not so few as was thought some years ago. The author thinks that the tendency of Russian workers, like Mazel, to advocate work for evolutive tuberculosis of the lungs is exaggerated. But he thinks that occupational therapy is indicated in some benign forms of fibrous or interstitial tuberculosis. Furthermore, he advocates work in cases of pneumothorax a few months after the collapse of the lung. Favourable results were found by the author in more than 200 cases. This opinion is contrary to the statements of Vaucher, Hirchberg and Weickel who allow hand work only after 1 to 3 years.

Not every type of work is suitable for occupational therapy. Some types should always be forbidden in cases of tuberculosis. They are, for example, night work; hard work; work in rooms with smoke, dust or toxic substances; nursing; or work under the influence of weather changes, like drivers or policemen. The best way to determine the capacity of tuberculosis cases for undertaking work seems to be post-sanatorial institutions or organizations like the Papworth village settlement. There exists in Spain a similar institution in Torrelvinca in the province of Barcelona.

X. *de la Quintana, P.* '*Higiene de los lugares de trabajo*,' pp. 239–296. (Factory Hygiene.)

The author here reviews suitable general conditions in factories: the construction of buildings, ventilation, environment, temperature, relative humidity, air currents in confined places. The last three factors are more important from the point of view of comfort and hygiene than the amount of CO_2 and atmospheric oxygen; they determine 'The rate of effective temperature' (in Spanish 'indica de temperatura efective'). Suitable apparatus, like the 'Terhumiter' of Bailey-Parsons, are described here. The psychological influence of the concentration of ions in the air is also discussed. There is also a short account on the influence of light and noise in industrial work.

XI. *López de la Garma, F.* '*Aspectos sanitarios de la traumatología del trabajo*,' pp. 297–313. (Hygienic aspects of occupational wounds and fractures.)

The author stresses the frequency of industrial accidents and its importance in modern life. In Spain one accident occurs every minute; every hour a worker is incapacitated; and every seven hours one is killed. The author thinks that this is a national problem and that prevention of these accidents and the care of casualties should be a state undertaking. A short account is given of first-aid measures in industrial accidents.

XII. *Melián González, A.* '*Visión y Trabajo*,' pp. 315–343. (Sight and Work.)

In this paper several problems are analysed: visual acuity, stereoscopic vision, photometric sight and eye fatigue. Speaking about colour blindness, the author says that in Spain the only reliable statistics are those of the 'Instituto Nacional de Psicotécnia.' In examination of 1296 persons colour blindness was found as follows:

Absolute c.b.	for red	3 per cent.
,,	for green	2·9 per cent.
,,	for violet	0·03 per cent.
Partial c.b.	for red	4 per cent.
,,	for green	5·01 per cent.

XIII. *García Miranda, A.* '*Patología profesional del aparato de la vision*,' pp. 345–356. (Occupational eye diseases.)

In occupations where workers have to be near furnaces, eye lesions are frequent. If the conjunctiva is permanently damaged the best treatment is by means of a graft taken from the neighbouring mucous membrane. Cataract is an occupational eye disease amongst workers in the glass industry. The cause of this type of cataract is not yet fully understood. According to Goldmann the cause is a thermic transformation of the infrared rays when they cross the iris. The author thinks that this hypothesis is the most satisfactory. The frequency of nystagmus in coal miners is another occupational disorder which has not been completely explained. Inadequate illumination has been considered as the causative factor, but the presence of a toxic factor in coal mines has also been put forward. In Spain Rubiera and Garcia Miranda have shown that nystagmus diminishes in coal mines with good ventilation.

XIV. *de la Quintana, P.* '*Accidentes eléctricos y su profilaxis*,' pp. 357–372. (Accidents due to electricity and their prophylaxis.)

Apart from the true accidents there are several disorders which are found in persons who work in an electrical field. They are characterized by hardening of the peripheral arteries, increased reflexes and special nervous lability. The true accidents are due to the contact with an electric conductor. The cause is the direct action of electricity upon the body cells and excitation of the peripheral nerves and central nervous system. According to some investigators the cause of death in fatal accidents is due to ventricular fibrillation, but de la Quintana thinks that general shock is the most important cause. Dantin, one of the editors of the present book, working in Berlin under Professor E. Schilf was able to confirm this hypothesis.

XV. *Tomé Bona, J. M.* '*Diagnóstico de las dermatosis profesionales*,' pp. 373–392. (Diagnosis of occupational skin diseases.)

XVI. *Daudén, F.* '*Profilaxis y tratamiento de las enfermedadas profesionales de la piel*,' pp. 393–413. (Prevention and treatment of occupational skin diseases.)

In these two papers a short account of the more important occupational skin diseases is given. Prevention and main lines of treatment are also discussed. The subject is too wide to be reviewed in two chapters and it is compressed.

XVII. *Dantín Gallego, J.* '*Saturnismo*,' pp. 415–433. (Lead poisoning.)

This occupational disease is of considerable importance in Spain which is a large producer of lead. In 1928

11,804 workers were employed in the mines and 2240 in the extraction of the metal. Danger of lead poisoning is also present in other occupations (about 150 according to the author) like painting, manufacture of electric accumulators, smelting and the ceramic industry. Symptoms of lead poisoning arise after the absorption of a few milligrammes; one or two milligrammes a day or ten milligrammes in a week are sufficient to cause trouble. From the point of view of industrial hygiene absorption through the respiratory tract is more frequent than the absorption through the alimentary canal. The cutaneous way is exceptional, but it is possible in cases where contact is established with gasoline containing lead.

The classical symptomatology of lead poisoning is described. The most frequent symptoms and signs are: anæmia, pallor, increased number of polychromatic red blood cells, basophilic stippling, haematoporphyrinuria, Burton's gingivitis, spasm of the colon, radial paralysis. The author thinks that the diagnostic value of basophilic stippling is of less importance than early workers believed.

The production of manganese in Spain has fluctuated extensively. In Huelva, the chief producer province, of 121 mines only seven or eight were working in 1934. There are two important types of manganese poisoning: one resembles Parkinson's disease, or multiple sclerosis, or post-influenzal encephalitis; and the other is a pneumonic type, studied for the first time in 1913 by Brezina.

XX. *de la Quintana, P.* '*Breve noticia de algunas tecnopatias*,' pp. 475–510. (A short note on some industrial diseases.)

The influence on industrial health of 21 chemical substances is briefly reviewed in this paper.

XXI. *Martín Retortillo, M.* '*El análisis químico en Medicina e Higiene del trabajo—Tóxicos metálicos—Análisis de gases y vapores*,' pp. 511–540. (Chemical analysis in industrial medicine and hygiene. Metallic poisons. Analysis of gases and vapours.)

This paper is chiefly a chemical study and is of little value to industrial hygiene. As complementary to the paper of de la Quintana on mercury poisoning, the amount of mercury in the mines of Almadén is given. The ore here contains 7–11 per cent. of mercury compared with 0·62–0·74 per cent. of those in Idria (Italy) the second most important world source. In the Italian mines there is no danger of mercury poisoning.

XXII. *Bonet Galán, R.* '*Gases de guerra. Higiene de su fabricación y manipulación*,' pp. 541–587. (War gases. Hygiene of manufacture and handling.)

The subject has been treated more from a military standpoint than from the point of view of industrial hygiene. The author is an army doctor and has been working at the centre of Chemical Defence in La Marañosa. He has had an opportunity to study German methods.

XXIII. *Dantin Gallego, J.* '*Noxas inhalatorias. Disolventes: classifación diagnóstico, sanitario en las distintas industrias, detección, protección*,' pp. 589–620. (Toxic substances absorbed via the respiratory tract. Solvents: classification and diagnosis in different industries. Detection and protection.)

Several substances are studied in this paper. The author has considerable experience in poisoning through spray-painting. On examining people doing that kind of work without protection he found the following symptoms of intoxication:

	Men	Women	Total
Lymphocytosis	4	12	16
Anisocytosis	2	4	6
Anaemia	1	2	3
Digestive disorders	3	7	10
Respiratory disorders ..	2	2	4
Bone and muscular pain ..	—	1	1
Dysmenorrhoea	—	4	4
Healthy	3	7	10

The author quotes the work of Bilbao* who has studied benzol poisoning in the printing industry. On examining 74 workers in that industry the following results were obtained:

Slight anaemia	63
Moderate or marked anaemia	21
Slight leukopenia	22
Marked leukopenia	7

At the end of this paper there is a short account of a peculiar form of poisoning found in the south of Spain in the olive oil industry. The residual oil is extracted by means of trichlorethylene and carbon bisulphide; and the poisoning is acquired through handling these substances.

Relation between Illumination and Visual Efficiency—The Effect of Brightness Contrast. WESTON, H. C. (1945). Industr. Hlth. Res. Bd. Rep. No. 87. H.M.S.O. Pp. 35.

The report describes investigations intended to test the value of a method suggested by A. W. Beuttell for determining the illumination required for the efficient performance of any kind of work involving visual discrimination.

Facility in seeing the object, or objects, concerned in any visual task depends upon certain characteristics of the object and upon the degree of illumination it receives. The characteristics of the object vary with different types of task, and so the illumination required is different for different tasks. Beutell's method involves, in effect, taking the task to pieces, assessing its principal characteristics and putting it together again in terms of the illumination required for its satisfactory performance; but the application of the method is dependent upon a previous determination of the relationship between each of the task characteristics and the illumination necessary to 'compensate' for it.

Among the most important of these characteristics are size and contrast. The results of an investigation of the effect of size on the illumination required have previously been published, and the present report deals with the effect of brightness contrast.

Brightness contrast is presented whenever juxtaposed surfaces or objects differ in brightness; and contrast of brightness or colour is essential for the differentiation of objects by sight. Brightness contrast may be numerically expressed in various ways, in terms of the physical brightnesses (stimulus intensities) involved.

The object of the investigations described has been to determine how the performance of simple visual tasks, differing only in the contrast involved, varies with (*a*) illumination, and (*b*) absolute brightness difference between the components of the contrast.

The results obtained are summarized in the following conclusions:

(1) With the same illumination, whatever its value within the range considered, the performance of tasks differing in contrast appears to be unaffected by this difference, providing the size involved is large (6 minutes) and the contrast does not fall below a certain value.

(2) When size is smaller, performance increases with increase of illumination in a different way, and reaches a different maximum for different contrasts, i.e. the relation between performance and illumination depends on the contrast presented by the task. The illumination for maximum performance varies inversely and the maximum performance varies directly with the contrast. Thus, with equal illumination, however high its value, equal performance of tasks presenting different contrasts cannot be obtained.

(3) Performance also depends on the contrast presented by the task, even if different contrast tasks are given different illuminations such that each task presents the same absolute brightness difference. But, at a

* Bilbao, R. '*la higiene del trabajo en le industrios del huecograbado*,' Publicaciones del Instituto Nacional de Previsión, 1933.

certain brightness difference, depending on size, performance reaches, or very closely approximates to, its maximum for each contrast within the range studied. Further, it is shown that when size is small (about 1 min.) the relation between relative performance (i.e. actual performance with any contrast expressed as a percentage of the maximum performance attainable with that contrast) and brightness difference is the same whatever the contrast of the task. It is also shown that, above a certain relative performance, the relation between this variable and brightness difference, for sizes up to 4·5 mins., is not much affected by the contrast of the task. Hence, it is possible to predict the illumination necessary to give approximately a certain percentage of the maximum performance possible with a task presenting any given size and contrast, within the limits considered.

(4) Experiments with a 'reverse' contrast of low order, having the reflection factor of the object greater than of the background, show that performance and relative performance are better at both the same illumination and the same brightness difference than for a similar 'normal' contrast.

Study of Certified Sickness Absence among Women in Industry. WYATT, S., assisted by DAVIS, NORAH M., DAWSON, W. M., HUGHES, D. E. R., MARRIOTT, R., and STOCK, F. G. L. (1945). Industr. Hlth. Res. Bd. Rep. No. 86. H.M.S.O. Pp. 34.

During the last six months of 1942 the sickness absence among 20,000 women workers amounted to 7·8 per cent. of the total number of days in the period. Diseases of the respiratory and digestive groups and functional nervous disorders accounted for most of this absence. Absences due to 'fatigue' were also fairly numerous and prolonged. During this period there was a fairly close resemblance between the incidence of functional nervous disorders and diseases of the digestive system.

The percentage of women who had no sickness absence in the period of six months was 45·3; the percentage who had absences of more than 28 days was 14·4. The most frequent cause of long absences were diseases of the respiratory and digestive groups and those diagnosed as 'nervous debility' and 'general debility.'

The amount of sickness absence of married women exceeded that of single women by 65 per cent.; the excess being most marked in diseases of the generative, locomotory and circulatory groups, in functional nervous disorders (including 'fatigue') and in absence, due to accidents. The proportion discharged for reasons of ill-health was also much higher among married women.

Sickness absence varied with age, the number of days lost through sickness being highest in the age group 30–50. In each age group married women had more sickness absence than single women, the increase being particularly noticeable in married women under 25.

Women in the longest service group (2–3 years) had fewer but longer absences than those recruited later. The proportion discharged for reasons of ill-health was also higher.

The amount of sickness absence varied according to the type and conditions of work. It was higher for production workers than for examiners, and was least for clerical workers. There was some evidence that sickness absence among women on day work was less than for women on shift systems.

In general, the results obtained in this investigation illustrate the importance of accurate and complete records of sickness absence, and the value of such records as an index of industrial health. They may also serve to direct attention to the loss in output due to sickness, and may stimulate industry to inquire more closely into the causes of ill-health. Finally, they should help to emphasize the importance of sickness records as a necessary foundation for any sound system of dealing with industrial diseases.

Resettlement of the Disabled in Work. FERGUSON, T. (1945). *Lancet*, **1**, 391.

To be successful the approach to the problems of disability must be individual and the disabled man must be kept in view until he is seen to be settled in work within his compass. The home environment must be considered and is often as important as the environment at work. Many disabled men have financial troubles: the wages they are able to earn are often too low for their responsibilities. Geographical considerations are important, sometimes the district in which a man lives does not offer scope for re-employment. A man should return to an industrial environment with which he is familiar: for instance, a wood worker may be unable to follow his trade, but given some commercial training his basic knowledge of woodwork might make him a valuable agent. In Denmark invalidity has been mitigated by the Invalidity Insurance Court; in the United States the approach has been by vocational placement with extensive job analysis. In Great Britain the passing of the Disabled Persons (Employment) Act has opened a new chapter in the care of the disabled; it contemplates their registration and resettlement, with a statutory obligation on industry to employ a quota of disabled persons.

Disablement and Employment. WATSON-JONES, R. (1945). *Lancet*, **1**, 411.

A disabled man should be an asset and not a burden. When treatment is completed his ability rather than his disability should be considered. His handicap can be minimized. He can be trained in almost every type of industrial and professional activity. There can be no greater degradation than to engage a man on duty which he knows to be unimportant, unnecessary and specially prepared as a concession. The compassionate approach is misplaced, and the charitable creation of artificial jobs is misguided. Good surgery and good medicine are of primary importance. Active exercise, massage, gymnastics, occupational therapy and recreational treatment have become known as medical rehabilitation. Treatment of disability can only be completed by vocational retraining and resettlement in the life of the community.

Aseptic Dressing of Wounds: Technique for Factory Surgeries. WILLIAMS, R. E. O. (1944). *Nursing Mirror*, June 24, Supplement ii–iv and 185.

This article is a plea for the employment of an aseptic technique for handling all the wounds—large and small—treated in factory surgeries. The most important sources of the microbes that cause wound sepsis are probably those infected wounds being treated in the surgery; and the most important vehicles by which microbes may be carried from one wound to another are the things that come into contact with the wounds: fingers, instruments, limb-rest, etc. A dressing routine has been designed, in collaboration with industrial nurses, for nurses working alone in factory surgeries. The steps may be summarized as follows: (1) Take a bowl and two pairs of forceps from the sterilizer and collect in the bowl all the material to be used for the dressing. To save time, mops for cleansing the wound may be kept ready moistened in lidded jars. (2) Remove the bandage from the wound, cutting it with scissors kept for the purpose and stored in disinfectant. (3) Dress the wound by the no-touch technique, using two pairs of forceps and taking material only from the dressing bowl; bandage the wound. (4) Record treatment and then wipe the limb-rest with disinfectant. (5) Wash and dry hands. (6) Get sterile bowl and forceps from the sterilizer for the next case, and then put the dirty bowl in. Emphasis is laid on the importance of planning the surgery to make the practice of the routine easy. (See GISSANE, MILES and WILLIAMS, *Brit. J. industr. Med.*, 1944, **1**, 90).

Methyl Bromide Poisoning. GRAY, P. H. K. (1944). *J. roy. mav. med. Serv.*, **30**, 214.

Toxic effects fall into three distinct groups: those brought about by pure gassing, the systemic effects of the vapour and the effects on skin and mucous membranes. In the first instance death may occur from anoxaemia or toxic paralysis of the respiratory centre. Mild systemic effects include headache, giddiness, diplopia, inability to accommodate and vomiting. Severe effects include signs similar to alcoholic intoxication with disorders of gait and co-ordination. Methyl bromide rapidly penetrates clothing, has an irritant effect on skin and mucous membranes and produces burns. Three cases of mild poisoning are recorded; they occurred in ratings working in the engine-room of a small invasion craft. The main points of interest in the cases were persistence of the cyanosis and sweetish odour in the breath, indicating that the elimination of the gas from the system is a lengthy process; the absence of any severe neurological and pulmonary symptoms despite the fact that a considerable amount of the vapour must have been swallowed and inhaled; the severity of the burns.

Methyl Bromide Intoxication. HOLLING, H. E., and CLARKE, C. A. (1944). *J. roy. nav. med. Serv.*, **30**, 218.

Five incidents which gave rise to methyl bromide poisoning with two deaths are described. In the first the ill-advised testing of remote control of a methyl bromide fire extinguisher caused a concentration of 5·4 per cent. of methyl bromide in the affected compartment. In the second, in the course of a fire in one part of the ship, the methyl bromide apparatus in another part of the ship was accidentally released and permeated the cabins of two officers. In the third incident three civilians working in the engine-room of a motor launch complained of symptoms; some days later the methyl bromide cylinders were tested and found empty. In the fourth case the unexplained release of methyl bromide in the engine-room of an M.T.B. resulted in methyl bromide vapour permeating into a mess-space. Three men lost their lives as a result. In the fifth incident accidental leakage of a methyl bromide fire extinguisher resulted in methyl bromide leaking into the wardroom of an M.T.B. Five individuals were in the wardroom: two died, one was unaffected. In the two fatal cases the concentration of hydrolysed bromine in the blood was 9·3 and 8·3 mgm. of non-volatile bromine per 100 c.c. In the two less severely affected cases it was 6·9 mgm. per 100 c.c. and was unchanged 11 days later when recovery had apparently taken place. Methyl bromide casualties will best be avoided by taking care in the maintenance of the methyl bromide apparatus.

Methyl Bromide Poisoning: Nervous Effects. CARTER, A. B. (1945). *Brit. med. J.*, **1**, 43.

An account is given of a boy of 17 who had worked at a methyl bromide producing factory for 18 months. During the 6 months before admission to hospital he had work in the refilling department, where fire extinguishers which had been insufficiently filled were re-opened and refilled with methyl bromide. He was a clumsy worker and there was an escape of gas with a peculiar stale odour. Two months before admission he noticed weakness of his legs with tingling in his toes and difficulty with speech. He developed burns on his hands. Later his hands became clumsy and his work slower. He developed diplopia, and he was unable to see objects close to him. On examination he was confused, had a slurring ataxic dysarthria and was unable to stand or walk owing to weakness of his legs. His pupils were dilated. He had slight motor inco-ordination in the upper limbs with diminished tendon reflexes. Abdominal reflexes were greatly increased. There was flaccidity of the lower limbs with diminished knee jerks and absent ankle jerks. The left plantar response was extensor and there was motor ataxia in both legs. There was precipitancy of micturition. After two days in hospital the symptoms began to improve. A week after admission he was greatly improved but showed nystagmus. Seven weeks after admission he was discharged with no residual sequelae and was advised not to return to employment where methyl bromide was used.

The Effect of Chronic Lead Poisoning on Arterial Blood Pressure in Rats. GRIFFITH, J. Q., and LINDAUER, M. A. (1944). *Amer. Heart J.*, **28**, 295.

Fifteen healthy albino rats weighing 200 g. were given 90 mg. of lead acetate daily, omitting every seventh day. This is equivalent to 70 mg. of metallic lead. The blood pressure, which was normal at the start, was measured every fifteen days. The blood pressure was measured four times in four animals, three times in seven animals and twice in three animals. All the animals survived until the thirtieth day, after which some were killed and some died. Four animals survived until the eightieth day. All the animals that survived forty days had a systolic blood pressure above 150 mm. of mercury and were therefore said to be hypertensive. The authors therefore concluded that chronic lead poisoning can produce arterial hypertension in rats.

The Absolute Efficiency of the Impinger and of the Electrostatic Precipitator in the Sampling of Air containing Metallic Lead Fume. KEENAN, ROBERT G., and FAIRHALL, LAWRENCE T. (1944). *J. industr. Hyg.*, **26**, 241.

Exposure to lead fume occurs in those industrial operations which entail heating lead to temperatures above 1000° C., when the volatility of lead becomes appreciable. Metallurgical operations, such as smelting and the preparation of certain alloys, are sources of this particular hazard, which is considered to be a peculiarly risky one as the particle size of lead fume is very small. Though previous investigations have been made by means of the impinger and the electrostatic precipitator on the fumes evolved by molten lead, the absolute efficiency of the methods used has not been ascertained.

In the present investigation true metallic lead fume was produced by means of a direct current arc (with one of the electrodes containing a pure lead core) in a current of purified nitrogen. The fume, diluted with air, was drawn into a large mixing chamber and thence through the impinger and the electrostatic precipitator. The lead fume was found to have an average particle size of 0·3–0·4 micron, and its x-ray diffraction pattern showed it to consist of lead for the greater part, and not lead oxide. Elaborate precautions had to be taken in order to get the maximum efficiency of sampling. Means were devised for measurement of absolute efficiencies by direct comparison of the amounts of lead retained by a sampling device with the total amount of lead drawn through the apparatus. A collecting device depending on surface contact with glass wool was found to be 100 per cent. efficient for collecting freshly formed lead fume, and it was found that an AC electrostatic precipitator of the type described was fully efficient at 25,000 volts, though not at lower voltages. The efficiency of the large impinger used was found to increase with the rate of air flow, and was nearly 100 per cent. efficient for the collection of freshly formed metallic lead fume at the highest rate of air flow. Its efficiency was independent of the atmospheric concentration of lead.

Dinitrophenol Cataract in the Chick: Effect of Age. ROBINS, B. H. (1944). *J. Pharm. exper. Therap.*, **82**, 301.

In 14 out of 15 chicks varying in age from 65 to 300 days, the ingestion of food containing 0·25 per cent. dinitrophenol sodium led to the development of opacities of the lenses. In 3 chicks opacities which developed during the first few days upon drug diet cleared up later. In one chick, 300 days old, no opacities were observed. There were fine vacuoles in lens fibres under the anterior capsular membrane and large destructive changes in the posterior portion of the lens. Lesions on the anterior portion of the lens usually healed in 6–10 days; those in the posterior portion persisted.

Skin Hazards in the Manufacture and Processing of Synthetic Rubber. SCHWARTZ, L. (1945). *J. Amer. med. Ass.*, **127,** 389.

The principal types of synthetic rubbers now manufactured are Buna S, Buna N, Butyl rubber and Neoprene. Buna S is made from butadiene and styrene. Most of the occupational dermatitis is caused by chemicals added to these components. Workers in the pigment room, those handling baled rubber exposed to soapslene and talc, those making coagulating solution and those making soap solution, should wear protective aprons and sleeves. Buna N is made by reacting butadiene with acrylonitrile; here dermatitis may occur from acrylonitrile which may leak out of enclosed pipes. Modifiers are primary skin irritants. Antioxidants (as phenyl B naphthylamine) are sensitizers. Barium chloride may cause a dry scaling eczema of the palms. Butyl rubber is made from isobutylene and isoprene. The workers in the mill sometimes develop burns and blisters of the hands from the hot rubber and dermatitis from the fumes of phenyl B naphthylamine and xylyl mercaptan. There is comparatively little dermatitis in the manufacture of neoprene. Little dermatitis need arise in the manufacture of synthetic rubber if plants are erected with planned precautions and safety recommendations are carried out.

Chemical Pneumonia in Workers Extracting Beryllium Oxide. VAN ORDSTRAND, H. S., HUGHES, R., and CARMODY, M. G. (1943). *Cleveland Clinic Quart.*, **10,** 10.

The exact process by which the beryllium oxide was manufactured is not revealed, but no fluorides were used. Three patients who were working in the process gradually complained of shortness of breath followed by a not very productive cough. The scanty sputum was mucoid or frothy, and occasionally blood-stained. The dyspnoea gradually became more severe and the patients became apprehensive. The course was febrile up to 100° F. The patients were cyanosed and had fine crepitations over the lower half of both lungs. Two patients were bronchoscoped; each showed a hyperaemic tracheo-bronchial mucosa; the aspirated secretions were negative to all pathogens. White blood counts were normal. Symptoms preceded x-ray changes by three weeks. The x-ray findings in order of progress were: (1) diffuse haziness of both lungs; (2) soft irregular areas of infiltration with prominence of the peribronchial markings; (3) absorption of soft exudative infiltration and the appearance of discrete small nodules scattered throughout both lungs; (4) clearing of lung fields. The course of the disease averaged about four months. Similar symptoms and x-ray changes were observed in six other patients besides the three described in detail.

Kerosene Intoxication. DEICHMANN, W. B., KITZMILLER, K. V., WITHERUP, S., and JOHANSMANN, R. (1944). *Ann. intern. Med.*, **21,** 803.

A case of fatal kerosene poisoning in a child is recorded. Vascular and parenchymal damage occurred in the lungs resulting in a diffuse lobular pneumonia. Kerosene damages the lung, not only as a result of aspiration but as a result of haematogenous transfer from the gastro-intestinal tract. Animal experiments proved this theory. Kerosene was administered to rabbits by mouth, intravenously and intraperitoneally. The changes in the lungs were the same by all routes. The tense yellowish-pink and red surfaces were moist, smooth and glistening and the upper lobes were marked posteriorly with subpleural haemorrhagic extravasations. The cut surfaces were covered with frothy serosanguineous fluid which oozed from the parenchyma and filled the bronchi and trachea. Histological section showed the vessels to be acutely congested with engorgement of the venules and capillaries and frequent extravasation into the interstitial tissue and alveoli. Alveolar oedema occurred after 12 hours. There was a patchwork distribution of emphysema and collapse. The picture bore a striking resemblance to that seen following the inhalation of phosgene and hydrogen chloride.

Industrial Exposure to Butanol. TABERSHAW, I. R., FAHY, J. P., and SKINNER, J. B. (1944). *J. industr. Hyg.*, **26,** 328.

The butanol of commerce is normal butyl alcohol, C_4H_9OH, and it is used chiefly as a solvent in conjunction with other solvents such as naphtha, butyl acetate and ethyl alcohol. It is used extensively in the manufacture of raincoats. Investigations were made in six different plants, and in all instances the chief complaints in order of importance were (1) irritation of the eyes, (2) disagreeable smell, (3) slight headache, (4) irritation of nose and throat, (5) dermatitis of hands. At three of the plants the butanol in the air was 100–115 parts per million as a maximum. It is considered that concentrations below 50 p.p.m. produce no important effects, and that systemic effects will not appear until 100 p.p.m. is greatly exceeded. Dermatitis was prevented almost entirely by the use of a protective ointment before work, and a lanolin emollient after it.

The Collection and Analysis of Halogenated Hydrocarbon Vapours employing Silica Gel as an Absorbing Agent. PERNELL, C. (1944). *J. industr. Hyg.*, **26,** 331.

Carbon tetrachloride and tetrachlorethylene alone were tested, but it is considered that the method employed should be applicable to other halogenated hydrocarbons. Air containing a known amount of the hydrocarbon was passed through an adsorption train consisting of two U-tubes, the first of which contained a drying agent, and the second, 10 gm. of silica gel. In the analysis, the gel containing the adsorbed vapour was digested with alcoholic potassium hydroxide, or an aliquot part of an alcoholic extract of the gel was burnt, and the products collected in sodium hydroxide. The chloride was determined by the Volhard method. With hydrocarbon concentrations of 90–340 p.p.m., such as may be expected in workroom atmospheres, and with sampling rates of 1–2 litres per minute, recoveries of 90–95 per cent. were obtained, whilst with concentrations of 2200–3000 p.p.m. and sampling rates of 6–9 litres per minute about 80 per cent was recovered.

Carbon Monoxide Polycythaemia. BRIEGER, H. (1944). *J. industr. Hyg.*, **26,** 321.

Polycythaemia is believed to be a regular sign of carbon monoxide poisoning, and it may be observed days or months after all carbon monoxide has been removed from the blood. Experiments were made by the author both on dogs and men, the COHb and Hb being determined by the spectrophotometric method which gives Hb determinations in the presence of COHb. Polycythaemia is believed to occur in the early stage of CO poisoning, but in the author's experiments on five men a 6–19 per cent. formation of COHb in the blood did not give it, nor did one of 9–10 per cent. in dogs. In a group of four severely poisoned dogs, two developed polycythaemia. In one of these dogs it reached its maximum two days after the exposure to CO (which caused 77 per cent. saturation), and the dog developed permanent polycythaemia, persisting for more than a year. Its red blood corpuscles were 35–45 per cent. above the original level, and its haemoglobin 20–40 per cent. above it. In experiments on chronic CO poisoning, six dogs were exposed during eleven weeks for 6 hours a day and 6 days per week to air containing 0·0096 per cent. of CO (causing 20 per cent. saturation). Five of the dogs showed an increase of Hb after three weeks of exposure, the increase being statistically significant in two of them. The Hb values reached their maxima after six weeks, the greatest increase being 45 per cent. After nine weeks the Hb and red corpuscles returned to about their initial level.

PROCEEDINGS OF THE ASSOCIATION OF INDUSTRIAL MEDICAL OFFICERS

THIRTY-NINTH MEETING

The thirty-ninth meeting of the Association was held at the London School of Hygiene and Tropical Medicine on March 24, 1945, Dr. J. C. Bridge in the chair. The morning session was devoted to private business and in the afternoon there was a discussion on ophthalmological problems and visual standards in industry.

Business Meeting

Honorary Membership.—Professor Thomas Ferguson, Professor of Public Health, University of Glasgow, was elected an Honorary Member of the Association.

Reports from Groups.—The Chairman reported on a recent meeting of the Group Secretaries with the Executive Committee of the Association. He stated that Group Secretaries on the whole were somewhat disappointed at the poor attendance of members at the various meetings that had been arranged. This was attributed very largely to travelling difficulties and to the fact that so many part-time men were unable to leave their practices. Many Group Secretaries were finding that visits to works and factories were more popular and were getting bigger attendances than at formal lectures. One or two of the smaller Groups had seriously considered disbanding but the Executive Committee had advised against this course, as, in the event of an industrial health service being formed, these small Groups would form a very useful nucleus for subsequent expansion. Dr. G. F. Keatinge (Nottingham) agreed with everything the Chairman had said regarding visits but thought there was still scope for joint meetings with, for example, members of the Public Health services. The feeling of the meeting was that the position of the Groups was satisfactory, considering all the difficulties.

Committee on Industrial Nursing.—The following resolution, proposed by Dr. P. Pringle (London) and seconded by Dr. A. Kefelas (Sunderland), was agreed:

> 'That there be set up a committee on industrial nursing consisting of three members, one of whom shall act as honorary secretary to the committee. The committee to be elected yearly and retiring members to be eligible for re-election. The committee to have the following terms of reference—" to study all matters connected with industrial nursing and to report from time to time to the Executive Committee." '

The following were elected members of this committee: Dr. P. Pringle (London); Dr. Patricia Shaw (London); and Dr. Catherine Swanston (Secretary).

Foreign Relations Committee.—The following resolution was proposed by Dr. Patricia Shaw (London), seconded by Dr. William Gunn (London):

> 'That a committee be formed for the purpose of establishing and maintaining relations with medical practitioners engaged in the practice of industrial medicine and hygiene (including teaching and research) in foreign countries. The committee to be elected yearly and to have power to co-opt, and retiring members to be eligible for re-election. The committee to report to the Executive Committee from time to time.'

This resolution was agreed and the following were elected members of the committee: Dr. Elizabeth Bunbury (London); Dr. W. E. Chiesman (London); Dr. A. Forgie (Dagenham); Dr. R. E. Lane (Manchester); Dr. T. Gwynne Maitland (Liverpool); Dr. D. C. Norris (London); Dr. P. Pringle (London), and the Honorary Secretary of the Association *ex-officio*.

Central Council for Health Education.—The Honorary Secretary read a letter from the Central Council for Health Education inviting the Association to become a constituent member of the Council and to nominate one member of the Association to the Council. The meeting agreed to accept this invitation and Dr. J. A. A. Mekelberg (London) was elected to represent the Association.

Institute of Ophthalmology.—Dr. H. F. Chard (Dagenham) was elected to represent the Association on the industrial sub-committee of the Institute of Ophthalmology for Research and Teaching (Royal Eye Hospital, St. George's Circus, London, S.E.1).

Bulletin of Hygiene.—The Chairman stated that Dr. E. R. A. Merewether (Factory Department, London) had asked him to draw the attention of members to the *Bulletin of Hygiene* as he thought that it would be of considerable assistance to them. Its scope had recently been revised and there was an enlarged section dealing with industrial medicine and hygiene; also there were many abstracts on other subjects which could not fail to be of interest.

Chair of Industrial Health at Manchester University.—The Chairman proposed that the congratulations of the Association to Dr. R. E. Lane on his appointment to the Chair of Industrial Health at Manchester University should be recorded in the Minutes. This was unanimously agreed. Dr. Lane took up his appointment in September, 1945.

Vision in Industry

At the afternoon session the speakers on the discussion on opthalmological problems and visual standards in industry were Dr. W. Jeaffreson Lloyd (Birmingham), Mr. Joseph Minton, Ophthalmic Surgeon, Hampstead General Hospital, London, whose paper appeared in the JOURNAL in April, 1945, and Mr. T. C. Summers, Surgeon, Western Ophthalmic Hospital, London.

Dr. Lloyd presented, briefly, a picture of the visual problems confronting the industrial medical officer in his work. In an environment which can be controlled by the employer it is of vital importance for him to see that eyes operate under the best conditions. Lighting standards for industry are inadequate, and legislation in this respect has not been bold enough. It is doubtful whether higher management always appreciate the value of good lighting. It is important that once good lighting is installed it should be serviced properly. Excuses given for poor maintenance are difficulty of access to fittings, and the difficulty of obtaining labour. Electrical engineers in designing lighting systems should pay more attention to the accessibility of fittings. This applies particularly to large and high shops. Frequently there is loss of candlepower from dirt on bulbs and reflectors. Installation of flood lighting operated from the walls of shops should be more carefully considered.

The industrial medical officer wants to know from the ophthalmic surgeon the methods he would recommend to assess eyesight of entrants into industry. The past health history is important but insufficiently studied. Once a suitable method is agreed how are the results to be interpreted? For a number of years Dr. Lloyd had an eye service in his factories. The ophthalmic surgeons who operate this service say that the man engaged on fine precision work seeks advice for his presbyopia about 4 years after he needs glasses; yet it appears that these men are capable of doing the fine work asked of them during this period. On close work such as viewing screws few complaints of eye strain come through to him or to the management. One reason for this may be that the eye strain is not constant, for in between periods of concentration there are periods when other operations such

as 'riddling,' take place which require little or no visual acuity. Thus the eye muscles can be relaxed and the girls can 'gaze into space.'

Another question that the industrial medical officer wants to ask is about the use of colour in industry, and what materials to use for backgrounds when close work is in operation.

Eye protection is a matter of great importance, and ophthalmologists should interest themselves more actively in the design of eye shields. The worker does not like safety devices such as goggles, and if possible the processes should be altered or safeguarded in some way so that flying particles do not come near the eye level of the operator. In the engineering industry swarf in the eye is a common problem. Frequently the first-aid man in the works removes swarf and grit with much skill. He may stand the patient back against a wall and flick out the foreign body with a bristle from a broom! In this connexion it is important to determine how much eye work the trained nurse in industry should herself undertake. In Birmingham the Association of Industrial Medical Officers arrange that State-registered nurses in industry attend the Birmingham Eye Hospital for two weeks' training. The course lasts for some three hours each morning, and during that time she obtains practical experience and training from an eye specialist. This experiment has proved of great value, and has very considerably increased the efficiency of nursing services in local factories. Dr. Lloyd was critical of the treatment that foreign-body cases obtain at general hospitals; and even at eye hospitals the out-patient departments are frequently so overworked that removal of adherent corneal foreign bodies is often left to a nurse with little training and experience. The doctor in industry saw cases early and perhaps felt that his results were something to be pleased about. But was there excessive digging for the last piece of rust? It was important too to recognize penetrating wounds of the eyeball and little should be done at the works by way of treatment; such cases must be referred immediately to an eye specialist. In his experience there was a considerable incidence of chronic conjunctivitis in the factory population associated perhaps with imperfect ventilation.

It is a moot point whether the factory should interest itself in providing an eye service at the place of work. In war-time it has been of great help to the worker to have this. Management benefits in that operatives are capable of more accurate work, but if such a service is to be installed it must use the ophthalmic surgeon for the examination of the eye and the dispensing optician for the provision of spectacles. It was unfortunate that a sight-testing optician service was introduced during the war into many factories of the Ministry of Supply; these opticians have cashed in on its publicity value. Where an eye service operates workers wishing to use the service should pass first through the hands of the medical officer. The ophthalmic surgeon should be a recognized specialist and preferably attached to a local eye hospital, and his or her remuneration should be by a sessional fee. Interest should be taken not only in refraction but in all eye and lighting problems in the works. Opportunity should be given to see cases other than those for refraction. Finally, Dr. Lloyd felt that there was a great need for increased research work on vision in industry. For example, more research might be carried out on the question of optical aids in fine work; at the moment there is much prejudice against this sort of help.

Mr. Summers approached the problem from the surgeon's point of view. But some years ago he acted as factory medical officer and was able to appreciate some of the difficulties. In eye accidents there is the bugbear of workmen's compensation always in the offing. It is now often a rule that employees, when taken on at a factory, have their visual standard recorded. The visual standard should be always recorded with glasses and a note made accordingly; this is a much more real standard of vision than the standard given without glasses. He had acted as consultant to a large industry for over twenty years and supported whole-heartedly the view that sight-testing opticians should not be employed on this work. The number of cases seen ran into over 15,000, and the following points are perfectly clear:

(1) It has been necessary to examine every patient under a mydriatic.
(2) Most of the glasses that patients are wearing, if prescribed by a sight-testing optician, are wrong.
(3) Most patients that used the service had astigmatism of varying degrees.
(4) There is scarcely a recognized eye condition, many of considerable rarity, which was not seen in the course of the ordinary refraction clinic. Cerebral tumours have been sent to hospital for operation on more than one occasion.

Glaucomas, cataracts and squints have been taken under his care and treated.

Emergency Treatment at the Works.—Lime burns should be bathed immediately with ammonium tartrate 10 per cent., before sending to hospital. Most of the lime can be removed by this means, and the subsequent treatment at hospital is rendered easier owing to the time saved. For the other caustics, acids and so on, simple bathing and the introduction of oil, paraffin, castor or almond, is of use before sending the patient to the ophthalmic department at hospital. Another condition which is continually occurring is the simple infective conjunctivitis, with much sticking of the lids and a moderate amount of discharge. These cases can quite easily be treated in the medical department, provided towel isolation is carried out, otherwise it can spread through a factory and a great deal of interference with production may arise thereby. There is nothing really to supersede the old-fashioned treatment of painting with silver nitrate, and if this is done early on and followed either by the introduction of albucid drops 10 per cent. or 30 per cent. three times a day, or flavine lotion 1 : 8000 or hydrarg oxycyanide 1 : 8000, a mild case will probably not have to be sent off work at all. It is important to paint eyelids properly in cases of conjunctivitis. Acute glaucoma is frequently mistaken for conjunctivitis, with disastrous results. There should be no difficulty in recognizing this condition as the following factors are present:

(1) There is considerable loss of vision.
(2) The pupil is usually partly dilated, oval, with the long axis vertical, and tension of the eye is hard.
(3) The patient usually complains of severe headaches on the affected side, which may be so bad as to cause vomitting.
(4) Conjunctivitis, which is a redness of the conjunctiva, is without discharge.

No treatment of any kind should be given at the works in cases of glaucoma unless the doctor has had some experience of ophthalmology; if the glaucoma is primary, the treatment is with eserin and subsequent operation, and if secondary and due to an iritis, treatment is with atropin, which would be fatal in a case of primary glaucoma, or one occurring in a case of central vein thrombosis or new growth.

Although the time factor is of importance in these cases, it is very much more helpful to the ophthalmic surgeon who is going to deal with the case, if it arrives completely untreated.

Foreign Bodies.—Perhaps the ophthalmic condition most frequently seen in industrial medicine is the small or large foreign body, entering an eye either slowly or at speed. The simplest of all injuries is that caused by a piece of grit entering an eye, blown in by an ordinary draught, or by a spicule of rust coming off an emery wheel or a lathe. In both these cases, the foreign body is usually superficial and small. One that has blown in, will usually bathe out, or failing that, it can be removed by the edge of a card. The piece of rust that one gets from an emery wheel is usually embedded in the surface of the cornea, and can often only be seen by using a magnifying glass. To remove this, cocaine 4–5 per cent. should be instilled three times at ten-minute intervals. This should completely cocainize the eye and allow the

foreign body to be removed with the full co-operation of the patient. Mr. Summers wished, if possible, to consign to an undignified and very deep grave that most popular of all ophthalmic instruments—the spud. This weapon can safely be described as the most dangerous thing that is still in modern use. It is true that by approaching the foreign body with the spud and digging hard, you can get it out, but you also remove a layer of cornea which will leave a permanent scar which very often results in diminution of the standard of vision. The removal of a foreign body by means of a needle, preferably a Bowman's cataract needle, or, if one of those is not available, even a large triangular needle such as is used in general surgery, is just as easy as using a spud, if not easier. It is the custom in ophthalmic hospitals when removing foreign bodies, to have the patient lying flat, or in the barber's chair with the head back on the headrest. An oblique light is shone on to the cornea and binoculars are worn by the surgeon, so that he can see the magnified foreign body with binocular vision and so realize the depth to which he has to go. By this means no more damage is done to the cornea than has been done by the foreign body originally, and in a great majority of cases this could be undertaken with absolute confidence and competence by the factory medical officer. But it is essential that one of the various types of binoculars be used. None of them is very expensive. The best of all is the Zeiss or Hamblin Type—incidentally the most expensive—and it also requires rather more getting used to than some of the others. That most frequently used in ophthalmic hospitals is the bucket type, which is very cheap and quite efficient. It does not have such a high magnification as the Zeiss or Hamblin binoculars, and has the advantage that it is not necessary for the doctor's ophthalmic correction, if any, to be introduced into the main lens of the binoculars. In the Zeiss or Hamblin type, the instrument has to be made to his pupillary distance and correction introduced into the object lens.

By far the greatest snag of all is the invisible foreign body, and next to the ophthalmic spud as the most dangerous instrument in the world connected with the eye is the rawl-plug tool and the hammer and chisel. Here a minute piece off the hard steel of the hammer can often enter the eye at speed and the workman will come and say that while using a hammer and chisel he felt something go into his eye. One may be lucky enough to see that something has gone into the eye, but in many instances nothing whatsoever can be seen, and it is not until months later when the man appears with a traumatic cataract and says he has lost the sight of the eye, that investigations for an intra-ocular foreign body are started. All cases of this type when they appear at hospital should be x-rayed, because it is so much better to try to remove the foreign body before it gets bound down by adhesions. Intra-ocular foreign bodies can be blown in by compressed air pipe lines and in blowing out castings, but these usually get no further than being embedded in the cornea, like the foreign body from an emery wheel. A man walking through an engineering shop where hammers and chisels are being used, or where high-speed lathes are working, may get an intra-ocular foreign body, even though he is wearing glasses. One recent case was not spotted until months afterwards when a traumatic cataract had developed with early siderosis. The man himself made no complaint at the time to anyone. He merely remarked that he thought something had hit him in the eye, but supposed it could not have done.

Another type is the large foreign body. In these cases the condition is nearly always such that it is necessary to send the patient to hospital. The snag is where a large foreign body hits the eye and produces no apparent injury at the time, but the condition is usually so painful that the cases are sent to hospital, so that if commotio retinae, dislocation of the lens, or detachment of the retina have occurred these conditions are spotted right away. All injuries by a large object should be sent off to the ophthalmic department or hospital, as either nothing is the matter or something rather serious, and in any event there is no treatment that can be done at the factory.

Head Injuries.—A comparatively minor head injury in a short-sighted person can produce detachment of the retina. From the high degree of danger of detachment occurring in a myope—about 7 diopters and higher—such employees should not be accepted for very heavy manual labour involving much stooping.

This condition can now be adequately treated, and some of the results have been gratifying.

Eye Examination of New Labour.—When taking on fresh labour, except in the case of highly skilled employees, stereoscopic vision matters little, provided the people are adapted to the conditions of monocular vision. In the case of older people with poor vision, an ophthalmic opinion should be obtained.

GLASGOW GROUP

At a meeting on March 28, 1945, Professor C. W. Illingworth, Regius Professor of Surgery at Glasgow University, read a paper on

The Peptic Ulcer, with special reference to factory conditions

During the past fifty years there has been a remarkable increase in the incidence of peptic ulcer, which now constitutes one of the commonest causes of prolonged disablement. The reports of the Department of Health on incapacitating sickness among the insured population show that in 1938 over half a million working days were lost from this cause in Scotland alone; and there can be little doubt that the position has become much worse since that time. Moreover, this figure takes no account of minor degrees of ill health, insufficient to put a man off work, but serious enough to impair his working efficiency. Peptic ulcer is especially important in relation to industry, for it appears to occur particularly in the best type of worker. In hospital practice over 60 per cent. of ulcer cases belong to social grade 3 as defined in the Census, that is to say, the group of skilled artisans, whereas less than 20 per cent. are unskilled workers. Moreover, general experience suggests that in all grades ulcer is apt to occur in the most useful type of worker, the keen, active, high-tension vagotonic type.

Under the auspices of a Sickness Records Committee set up in Glasgow by the Nuffield Trust we have recently undertaken a survey of peptic ulcer which has brought to light many features of special interest from the standpoint of industrial conditions. Up to the present we have restricted our survey to perforated ulcers, for which the data are more readily obtainable. There are obvious difficulties in collecting reliable morbidity statistics for peptic ulcer as a whole, since this disease is not notifiable, is not commonly fatal, and does not even as a rule require hospital treatment; but for perforated ulcers it is possible to obtain exact figures, not only for the present time but also for past years. Our survey has covered the region which includes Glasgow and the adjacent counties and is mainly based upon admission to the three main voluntary hospitals which are known to treat almost exactly 80 per cent. of the perforations in this area. It extends over the twenty-year period 1924–43 and includes over 7000 cases. The increased incidence of peptic ulcer as a whole is reflected in the number of perforations, which increased from rather less than 200 in 1924 to rather more than 400 in 1938. Then there was a rapid rise culminating in a high peak in the winter of 1940–41, followed by an equally rapid fall in 1942–43. These changes almost entirely concerned duodenal ulcer, whereas the rate of gastric perforations remained almost stationary.

A special study was made of the increasing incidence in 1940–41. A similar increase in London and Bristol had coincided with the periods of air bombardment in these cities. In Glasgow, on the other hand, it anticipated them by a margin which though very narrow is quite definite. It will be remembered that in Glasgow, apart from a few desultory raids, the first air attacks were

the heavy bombardments of March 13–14–15, 1941. That month also saw the highest incidence of perforations, with a total of 86; but examination of the records showed that no fewer than 41 of these occurred in the first twelve days of the month, i.e. before the raids began. It is thought that, while the local air raids could therefore not be incriminated, the general state of nervous tension over the war situation may have been a factor as also may have been the physical weariness resulting from the great increase of overtime work and civil defence duties at that time. This relation to overwork and tiredness has been brought out by several other findings in our survey. In an analysis of the hour of perforation it is seen that the most common time of perforation is in the late afternoon. In our follow-up inquiry I have been struck by the large number of men who state that the perforation occurred within a few minutes of the end of their working day. The relation to fatigue is also brought out by an analysis of the case incidence by days of the week, which shows that there is a statistically significant drop in the number of perforations occurring on Sundays and Mondays compared with other days. Many patients with active painful ulcers take the opportunity of the week-end to stay in bed, and it almost looks as though this period of rest gives a partial and temporary reprieve from perforation. Lastly, there is a curious variation which may possibly have a similar explanation. Perforations are far less common in August, September and October than in the other months, and while this may possibly be attributable to the warmer weather or even to better dietary, the most likely explanation is that it is related to the holiday season. There is thus a good deal of evidence to relate perforations with periods of physical fatigue. In the same way it seems likely that fatigue is one of the many factors concerned with the progress of non-perforating ulcers.

Since peptic ulcer is becoming such a formidable problem it is clear that the question of treatment demands a much wider approach than has been attempted in the past. It is no longer a question of alkalies and diet or operative treatment. The problem is a social and industrial one. Every case demands a full investigation into the domestic and working conditions, and there is a need for a much closer link-up between the family doctor, the hospital and industry. At the Western Infirmary in Glasgow we have made plans for setting up a special ulcer clinic which may be able to achieve this co-ordination. Owing to lack of staff and lack of funds it has not yet been possible to get it begun, but I am hopeful that both these difficulties will soon be solved. In the meantime under the auspices of the Nuffield Committee we have made a beginning by appointing a whole-time social worker who interviews the patients in hospital, visits them in their homes and inquires into their conditions of employment. Although this appointment was made only a few months ago it is already showing useful results, and there is no doubt but that it will prove an essential element in our ulcer service.

The organization of treatment for peptic ulcer cannot be complete without attention to the question of canteen feeding. In our follow-up survey we have paid particular attention to this matter, and, valuable as factory and other canteens are for healthy people, they are at present quite unsuitable for ulcer patients. Indeed, the great majority of our patients assert that they do far better with the old-fashioned carried ' piece ' than with a canteen meal. Very few canteens in the Glasgow area make special provision for workers on a dietetic regime. In view of the frequency of ulcer and its importance as a cause of industrial disablement, this matter might well receive the urgent attention of industrial medical officers.

At the same meeting a second subject for discussion was presented by Mr. Roland Barnes, Orthopaedic Surgeon, Western Infirmary, Glasgow, who read a paper on

The Painful Shoulder

Painful lesions of the shoulder joint form an important part of orthopaedic practice, and are one of the common causes of prolonged incapacity in the industrial population. Pain in the shoulder is commonly regarded as being due to ' fibrositis ' or ' periarthritis ', and no attempt is made to relate symptoms to the underlying pathological process. Until we make a real endeavour to diagnose the lesion responsible for pain in the shoulder, our treatment will continue to be empirical, and our results unsatisfactory. This neglect and misunderstanding of injuries of the shoulder joint is largely responsible for the prolonged periods of incapacity. The other factor is the difficulty we in hospitals experience in obtaining graded work for these patients, which alone can complete their rehabilitation and hasten a return to their pre-accident employment.

The majority of painful lesions of the shoulder occur in the heavier industries. They are especially frequent in the shipbuilding industry; this may be due to the long hours riveters have to work with their arms above the shoulder level. The common causes of pain in the shoulder are: (1) tears of the supraspinatus tendon; (2) degenerative changes and calcified deposits in this tendon; (3) lesions of the subdeltoid bursa which frequently lead to adhesions between the musculo-tendinous cuff, and the overlying deltoid and acromion process; and (4) the condition frequently known as ' brachial neuritis ' but now thought in most instances to be due to a protusion of a cervical intervertebral disc, which causes pressure on one of the lower cervical nerve roots.

Anatomical features.—The supraspinatus muscle is inserted into the greater tuberosity of the humerus, in common with the infraspinatus and teres minor muscles. These three muscles have a common tendon of insertion (sometimes called the musculo-tendinous cuff) which blends with the capsule of the shoulder joint. Between the musculotendinous cuff, and the deltoid and acromion process lies the subdeltoid bursa. Adhesions between the walls of the bursa prevent normal gliding movement between the capsule of the shoulder joint and the deltoid; this is the chief cause of a stiff and painful shoulder. The movement of abduction of the arm at the shoulder joint is initiated by the spinati group of muscles. If these muscles are out of action the deltoid cannot abduct the arm by itself, it merely approximates the deltoid tuberosity to the acromion. A tear of the musculo-tendinous insertion of the spinati will therefore interfere with abduction. The extent of the interference depends on the size of the tear. If the tear is complete active abduction is impossible. How common are these tears of the musculo-tendinous cuff? Codman and Akerson in 1931 reported the results of a post-mortem examination of 200 shoulders. They found 32 per cent. of the shoulders showed old ruptures of the supraspinatus tendon. There is no reason to doubt the veracity of these findings for they were confirmed by other observers. This being so it is clear that many minor tears must give rise to few symptoms.

Clinical Features of a Tear of the Supraspinatus Tendon.—This injury is commonest in middle-aged labouring men and it seems to occur with especial frequency in the shipbuilding industry. The patient usually gives a history of a wrench of the shoulder, followed by inability to lift the arm, and severe pain referred to the insertion of the deltoid, features which often lead to the diagnosis of a ' strain ' of the deltoid muscle. If there is a large tear, the patient is quite unable to abduct the arm more than about forty-five degrees, this range of movement being accomplished by rotation of the scapula on the chest wall. The deltoid is seen to be acting strongly, which at once excludes a circumflex nerve palsy as the cause of the disability. A full range of passive movement is possible when the arm is at right-angled abduction, but the patient complains of a sharp twinge of pain as the injured tendon passes beneath the acromion process. Once the arm has been passively abducted to a right-angle the patient can usually complete the abduction movement by his own effort; he has no difficulty in adducting the arm until it is just below the right-angle, when the limb drops powerlessly to the side. Apart from these features the only other abnormal finding is sharply

localized tenderness over the greater tuberosity of the humerus just below and in front of the anterior edge of the acromion process. These features are common to all supraspinatus tears, except that in some of the small tears, the patient may be able to actively abduct the arm but with much reduced power, and pain when the arm is at about right-angled abduction. Unless adequate treatment is given the disability may persist for months or years and the patient often develops all manner of trick movements, which together with the paucity of clinical signs may lead to a charge of malingering.

Treatment.—There is still much difference of opinion regarding treatment. Some surgeons advise operation on all cases where the patient is unable to abduct the arm. Unfortunately there is no easy way of knowing what is the size of the tear, and many tears will heal or at least give satisfactory functional results with conservative treatment. Operative repair is by no means easy, and for these reasons treatment is preferable in an abduction splint for eight weeks with the arm in full external rotation, which allows the two ends of the tendon to be approximated to each other as closely as possible. The results on the whole have been reasonably satisfactory. For the small tears where active abduction is retained the tender area in the region of the tuberosity is injected with 1 per cent. novocaine; this may need to be repeated on three or four occasions. The patient is encouraged to use the limb actively, but is not allowed any strenuous exercises for several weeks until the pain in the shoulder is completely relieved. If this fails, then a period of rest in an abduction splint is prescribed. Operative intervention is seldom called for.

Supraspinatus tendonitis.—Degenerative changes in the tendon may occur in middle-aged labouring men without any specific injury. The symptoms are very similar to those of an incomplete or partial tear. In addition to pain on movement, there is often severe pain at night, when lying on the affected shoulder. The condition is frequently called (one can hardly say diagnosed) ' brachial neuritis '. Calcified deposits may appear in the tendon, and if some of it escapes into the subdeltoid bursa, it at once sets up an intense reaction, with very severe pain in the shoulder. One has only to see one of these patients to be impressed by the severity of the pain which makes any sleep or rest impossible. Superficially the symptoms and signs resemble an acute arthritis of the joint, but the fact that the tenderness is confined to the region of the greater tuberosity is typical of an acute subdeltoid bursitis. The pain usually settles spontaneously in a week or ten days leaving a stiff shoulder due to the dense adhesions within the bursa. The pain of degenerative lesions, and small calcified deposits in the tendon can usually be relieved by the injection of 1 per cent. novocaine into the tender area, but several injections may be required. If the deposit is large, then surgical intervention is indicated. Complete removal is by no means easy as the calcified material is intimately incorporated in the tendon.

Cervical Intervertebral Disc.—Another cause of pain in the shoulder, which has recently been the subject of several papers, is protusion of a cervical intervertebral disc. The protuded disc if laterally placed may press on one of the cervical nerve roots as it passes through the intervertebral foramen. The seventh cervical nerve root in most commonly involved, and the patient complains of pain in the shoulder radiating down the radial side of the arm to the index finger and thumb. In addition there are usually other signs of a root lesion such as sensory changes, parasthesia, and absent reflexes. The triceps jerk is the reflex which is commonly depressed or absent. This condition frequently follows a minor strain or injury to the neck and is readily relieved by rest in bed and head traction.

Resettlement at Work.—Returning these men back to their pre-accident employment presents much greater problems than diagnosis and treatment. Treatment is continued in the physiotherapy department at hospital until there is a full range of painless movement in the shoulder, or until there has been no progress in the range of movement after several weeks treatment. Most of these men are still unfit at this stage to return to their ordinary job. They require further reconditioning which can seldom be obtained outside of industry. In other words they require modified work—not light work—which encourages active use of the injured arm and shoulder, and is progressive, so that there is a gradual build up of muscle power until it equals that of the opposite normal shoulder. It is practically impossible to obtain work of this type and as a consequence the disability drags on for month after month. It is true, of course, that many patients are quite willing to remain on compensation with a view to getting a better lump sum settlement, but that does not excuse industry from finding some way of helping those patients who are willing and anxious to return to work.

> The following case is typical of many. W.P., a hammerman, aged 32, tore his left supraspinatus tendon on June 30, 1943, whilst striking with an 8-lb. hammer. He was treated in an abduction plaster for seven weeks, and then attended the physiotherapy department. In October, 1943, the joint was manipulated. Five months after injury he had a full range of painless movement in the shoulder, but the muscles around the shoulder were still much weaker than normal. At this stage modified work was suggested and the patient was readily agreeable. For the next seven months repeated but unsuccessful attempts were made to obtain modified employment. In July, 1944, twelve months after injury, the patient was becoming extremely depressed. The hospital almoner then suggested that he should go harvesting. This was arranged and proved quite ideal. The stacking of corn and similar work was just the type of job needed to strengthen his shoulder muscles. Six weeks later the patient returned to Glasgow a different man. He was in good health and spirits and had considerably increased the bulk and power of the shoulder muscles. Nine days later he returned to work—slightly modified in that he was not asked to do full-time hammering. Two months later, sixteen months after injury, he returned to full employment.

Industry, as I see it, cannot afford to ignore this problem. How is it to be solved? Clearly the best solution is a rehabilitation workshop on the Austin pattern. It is doubtful, however, if any one firm in the Glasgow area is large enough to operate a shop of its own, and, in any case, such a shop would only be available to the injured employees of that one industry. The ideal solution would be a communal workshop, run by joint effort and available to all. Unfortunately such a scheme still seems far from attainment, though I have no doubt that given plenty of enthusiasm and push—particularly from members of this Association—we shall eventually get what we all so much desire. Can anything be done meantime? This suggestion may or may not be practicable: a survey should be made of the various processes in each factory with regard to their suitability for the rehabilitation of various types of injury. The processes would need to be simple, such as could be quickly learnt by an unskilled workman. Finally, there must be genuine co-operation between managements and trade unions, for without it nothing can succeed. Is it too much to ask that the sacrifices of principle that were readily made by all when this country was in danger should also be made for the thousands of workpeople who are injured every year in our factories?

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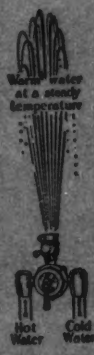

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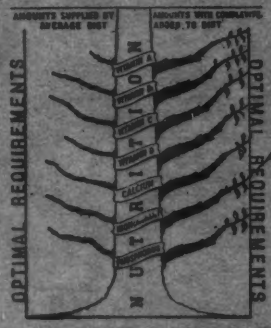

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